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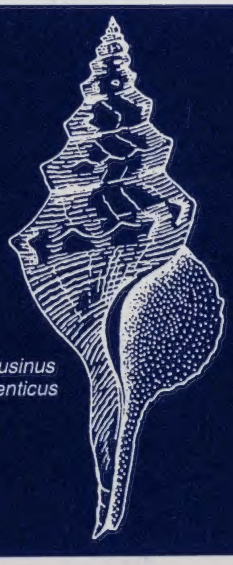

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BRITISH ARMY AND COLONIAL FORTIFICATIONS IN NORTH TARANAKI, 1865-69

NIGEL PRICKETT

Abstract. British Army and colonial fortifications of the Taranaki Wars in the years 1865-69 are described. During this period European success in the struggle was ensured by the settlement of European farmers on confiscated land, to deny Maori the resources to continue the fight, and at the same time secure the settlers' major objective which was land. Twenty-three forts include earthwork redoubts, and timber stockades and blockhouses. In each case the reason for establishment of the post is outlined, along with a brief history of the military occupation. The form is described from historical evidence and surviving archaeological remains. This is followed by a summary of the form and purpose of European fieldworks in north Taranaki throughout the campaigns of 1860 to 1869.

KEYWORDS: European fortifications; historical archaeology; New Zealand Wars; Taranaki; redoubts; stockades; blockhouses.

INTRODUCTION

The following is the third article in a series describing the purpose, history, form and archaeology of field fortifications relating to the Taranaki campaigns of the 1860s. The first dealt with Maori and European works of the First Taranaki War, 1860-61 (Prickett 1994a). The second covered the opening phases of the Second Taranaki War, in this case including only European works (Prickett 1996). In the present article I describe British Army and colonial fortifications of the years 1865-69.

The north Taranaki region extends from Paraninihi (White Cliffs) in the north, to Opunake in the south (Fig. 1). In the 1860s this was an isolated province of Pakeha New Zealand, in which the fighting also was quite remote from that taking place in other parts of the country. It was not until 1865 that European land forces in Taranaki made contact with troops campaigning out of Wanganui.

The fighting which took place in north Taranaki in 1860-69 was concerned largely with the expansion of European settlement and government in the region, and with resistance to this process by Maori. The war which broke out in 1860 over the disputed sale of land at Waitara ended without resolution, the great questions between the two races unresolved. In the north, British troops held Waitara for which the Governor risked war. South of New Plymouth, Maori forces held the outlying Tataraimaka Block on which European farmers had been settled since the 1840s.

Fighting began again in 1863 when Governor George Grey set about re-occupying Tataraimaka without first giving up Waitara. He then repudiated the Waitara purchase, and withdrew the Waitara and Sentry Hill garrisons. But political and military considerations soon

Fig. 1. North Taranaki showing European fortifications of the years 1865-69.

made his predecessor's ambition for the 700 acre Waitara Block seem modest by comparison. Under the terms of the 1863 New Zealand Settlements Act, confiscated Maori land was to be given over to European farmers, many of them military settlers recruited on the declining goldfields of Australia and Otago. The process would dispossess Maori of their land, and so deny them the resources for continuing the unequal fight. The process was one in which Maori were quite simply "swamped", as historian James Belich (1996:249) succinctly puts it.

The European military campaign from 1864 takes its shape from the systematic settlement of Maori land. In the period covered here the struggle for Taranaki was decided. Some of the works described here relate to the military movements of campaigning troops, but most are concerned directly with the occupation of land.

Twenty-three fortifications are described in their historical order, grouped into five episodes.

"South to Stoney River" completes the story of the summer 1864-65 return to Tataraimaka which was begun in my last work (Prickett 1996:43-45), and outlines the related occupation of Maori land to Stoney River which was to be the frontier of European settlement until the Parihaka Campaign of 1880-81. "Closing off the north" describes the movement to Pukearuhe, which prevented Maori reinforcements entering Taranaki from that direction. This was the last of three movements which isolated Maori fighters in the region; the others which closed the coastal and inland routes from the south are described in my previous article.

"Beyond Stoney River" introduces Warea and Opunake Redoubts, from which troops put pressure on Maori fighting strength in the bush country inland of Cape Egmont, and secured the European farming settlement north of Stoney River (Hangatahua). "Taking up the land", deals with blockhouses erected at military-settler farming districts in north Taranaki. The last section describes military activity beyond Waitara River in 1869, after a Maori raid on Pukearuhe caused European forces to withdraw from that isolated post. By 1870 European settlers taking up confiscated land were rapidly transforming Taranaki's demographic, political and economic landscape.

The archaeological fieldwork and historical research for this study was carried out mostly in the late 1970s, as part of a Ph.D. programme at the Anthropology Department, University of Auckland. Regular visits since then have allowed me to record changes to the sites. New Zealand Archaeological Association site record numbers and map references for the sites are given in Appendix 1.

Throughout this work the following abbreviations are used: AC for Armed Constabulary, LINZ for Land Information New Zealand, NP for New Plymouth, TMS for Taranaki Military Settlers, and TMV for Taranaki Militia and Volunteers.

SOUTH TO STONEY RIVER

TATARAIMAKA BLOCKHOUSE

The re-occupation of St George's Redoubt in November 1864 (described in Prickett 1996:8) was followed by the return of European settlers to Tataraimaka, which they had left early in the First Taranaki War. In a letter to the Assistant Military Secretary, Auckland, the officer in command of British troops in Taranaki, Colonel H.J. Warre, sought permission to erect two blockhouses in the Tataraimaka district, "similar to that recently erected at Dingle's Farm" (NP Garrison Quarter Master Letter Book, 3 Dec 1864).

The site for one of these was chosen on 22 January 1865, Warre writing in his journal, "... accompanied by Mr Atkinson CM Clarke and I rode round the Tatara Block, decided to place a Blockhouse on Mr Rawson's land". On 28 February 1865 the new post was occupied by one officer, one sergeant and 21 rank and file of Captain McKellar's company of Military Settlers from nearby Timaru Redoubt (NP Garrison Quarter Master Letter Book, 27 Feb 1865; *Taranaki Herald* 11 Mar 1865).

When McKellar moved to Tuahukino in April 1865 Tataraimaka was taken over by Captain Carthew's company, then engaged in road making near the Kaihihi River (NP Garrison Quarter Master Letter Book, 18 Apr 1865). The blockhouse was locked up in September 1866 when local forces were sent south to Patea (TMS Memo Book, 26 Sep 1866). It was re-occupied the following month, but soon after abandoned by its permanent garrison to be maintained only by local settlers as a militia post.

The February 1869 Maori attack on White Cliffs saw a last brief re-occupation of the post, with Sergeant Carpenter going to Tataraimaka to take charge of 12 settlers of the district (TMV

Order Book, 16 Feb 1869). An 1869 Colonial Defence Office report states that the blockhouse, with accommodation for 25 men, plus one officers' and one store room, was then in good repair (AD35/12).

The location of Tataraimaka Blockhouse can easily be determined. Dr T.E. Rawson owned 150 acres on Pitone Road (Crown Grant Record Map, Wairau & Cape, LINZ, New Plymouth), and the blockhouse is marked on this land ("Site of Old Block House") on the relevant block sheet (Cape II (14/4A), LINZ, New Plymouth). The site is on a prominent knoll 100 m west of the junction of Pitone Road and the present main road. A later farm house may have erased any archaeological remains of the blockhouse. The present house is forward of the blockhouse site.

The Tataraimaka Blockhouse was probably of the standard two-storeyed defensible form. Evidence for this is Warre's stated intention to erect a building similar to Dingle's Blockhouse (for which, see Prickett 1996:29), and a *Taranaki Herald* report of 26 July 1871 which refers to a lightning strike on the "bottom room".

The *Taranaki Herald* of 11 March 1865 states that, "another blockhouse is to be erected on Mr Cutfield's land". George Cutfield, who was for a time Superintendent of Taranaki Province, owned 298 acres on the west side of the junction of Greenwood and Timaru Roads, and another block east of the present main road and upper Timaru Road (Crown Grant Record Map, Wairau & Cape, LINZ, New Plymouth). There is no evidence that this second post was ever built.

STONEY RIVER REDOUBT

On 14 December 1864 Grey wrote to General Cameron setting out the government's objectives in the Taranaki and Wanganui districts. The immediate aim in Taranaki was, "...such occupation of the country from Tataraimaka southwards as will secure for settlement a block of land between Tataraimaka and the Stoney River" (AJHR 1865 A-4). The necessary orders were soon given, and on 25 January Colonel Warre reported to the Deputy Quarter Master General, at Headquarters in Wanganui,

> I have the honor to report for the information of the Lieut General Commanding that the Dett 43rd Light Infantry stationed at Tataraimaka under Command of Major Colvile, with a 12 pr Armstrong Gun, marched thence on the morning of the 23rd instt and occupied a position on a commanding knoll on the right bank of the Stoney (Hangatahua) River, about four hundred yards from the River and a mile and a half inland, without any opposition being offered by the Rebel Natives.
>
> A Redoubt is being erected on the site selected under the superintendence of Lieut Ferguson R.E. (NP Garrison Quarter Master Letter Book, 25 Jan 1865)

Warre lists Colvile's force as follows: Royal Artillery – one captain, three rank and file; Royal Engineers — one subaltern, one sergeant, four rank and file; 43rd Regiment – one field officer, two captains, six subalterns, nine sergeants, eight drummers and 197 rank and file.

Stoney River was to be the frontier of effective European control and settlement south of New Plymouth for 15 years, until the Parihaka Campaign of 1880–81.

The redoubt thrown up at Stoney River was at first 'Te Ngana' or 'Ngana', the name 'Stoney River Redoubt' only gradually coming into use. On 11 February 1865 the *Taranaki Herald* reported the 'Ngana Redoubt' complete, and another camp set up nearer the coast, about three-quarters of a mile from the Stoney River ford. The reason for the new camp is given in Colonel Warre's diary:

> The Redoubt [Stoney River] is very badly built – unflanked – & much too small for the number proposed viz 100 men... Selected a site near the [redoubt?] where to place the men who cannot be accommodated in the Redoubt & afterwards visited Capt Corbett's Co of Mily Settlers at Kaihihi. (Warre Journal 2 Feb 1865)

The redoubt never seems to have been satisfactory; in April 1865 Warre was still grumbling: "Mr Ferguson very obstinate about the Redoubt at Stony River which is too small & very badly defended nearly altogether unflanked" (Warre Journal 12 Apr 1865).

On 20 February 1865 the 43rd at Stoney River was reduced to eight officers, seven sergeants, six drummers, and 150 rank and file, still under Major Colvile. Lieutenant Colonel F.H. Synge, in command of the 43rd in Taranaki, was instructed:

> You will observe that the strength of the officers is not reduced, as it is still necessary, owing to the smallness of the Redoubt at Te Ngana to keep up two camps at Stony River. (NP Garrison Quarter Master Letter Book, 18 Feb 1865)

On 12 April Colvile was at the second camp, in command of the whole force, with Major Close in charge at the redoubt (Warre Journal 12 Apr 1865).

On 1 May the 43rd was ordered to Warea and Opunake. Stoney River was taken over by Captain Percival's company of Military Settlers (NP Garrison Quarter Master Letter Book, 8 May 1865). On 1 July the garrison still comprised a T.M.S. company, plus four men of the Royal Artillery and seven Commissariat and Transport Corps (WO 0270.II:434). The 43rd, with Lieutenant Colonel Synge and headquarters, returned to Stoney River on 28 October 1865 (NP Garrison Order Book, 25 Oct 1865). There is no mention now of two positions. At the end of November Synge returned to town, leaving Captain Horan in charge (NP Garrison Order Book 20 Nov 1865).

In February 1866 the 43rd was replaced at Stoney River by the 50th (The Queen's Own) Regiment, lately arrived from Patea. At first the 50th established its headquarters at Stoney River under Colonel Weare (Fyler 1895:286). When Weare replaced Colonel Warre as commanding officer in Taranaki, Captain Creagh took over at the southern outpost in the winter of 1866. On 20 August the 50th at Stoney River included 88 rank and file (AJHR 1867 A-1). The regiment withdrew from Opunake, Warea and Stoney River in May 1867 (*Taranaki Herald* 4 May 1867). Stoney River was not reoccupied.

In Figure 2 Colonel Warre shows the auxiliary camp in the foreground, with a cart road near the line of today's Kaihihi Road leading to a redoubt on top of a low hill. Earthworks which might relate to the redoubt can be seen in New Zealand Aerial Mapping aerial photograph 4341/5, taken in February 1970, on the lahar mound south-east of the corner of Kaihihi and Brophy Roads. Any remaining evidence was destroyed in the early 1970s when the present house was built on the site. Evidence of the camp has not been found.

ORONGOMAIHANGI

When the 43rd advanced to Stoney River in early 1865, Military Settlers also moved into the district, camping for a time at Orongomaihangi, Tukitukipapa and possibly also at Puke Ti. In spring 1865 they were at Okato where a township was laid out and rural sections of 50 acres surveyed for the men.

Captain Corbett's No 2 company occupied Orongomaihangi in January 1865 (*Taranaki*

Fig. 2. "Mt Egmont from the Camp near Stoney River", H.J. Warre. (Rex Nan Kivell Collection, National Library of Australia.) The redoubt with tents inside can be seen in the middle distance.

Herald 4 Feb 1865) – somewhere near the old Kaihihi River pa taken by General Pratt in his spring 1860 sapping practice for later operations at Waitara (see Prickett 1994a:49-51). The new post protected the coast road to Stoney River. The present inland road was constructed later in 1865. When Corbett's company marched north to No 6 Redoubt (Huirangi) on 23 February 1865 (Prickett 1996:38) they were not replaced at Orongomaihangi.

TUKITUKIPAPA

Military Settlers next occupied Tukitukipapa, the *Taranaki Herald* of 4 March 1865 reporting,

> Southwards, Orongomaihangi still remains unoccupied. Captain Carthew, who marched through the town on Saturday last with his company, has formed a temporary encampment at Tukitukipapa, where he will remain until the roads which Lieutenant Ferguson, R.E., is at present laying out are completed, when the company will move on to the beautiful district of Puketehe.

Tukitukipapa was the scene of an agreement with the local Ngamahanga tribe on 22 January 1865 (G16/8), as a result of which the inhabitants moved south of Stoney River to Moketuna (G16/7). Tukitukipapa was at that time reported as a pa, "...formed of earthworks exactly after the models of English redoubts, with flanking angles and ditch complete" (*Taranaki Herald* 28

Jan 1865). On 18 March the *Taranaki Herald* reported that Captain Carthew's No 4 Company was continuing with an inland road from Tukitukipapa.

Tukitukipapa is marked on the NZMS 177 series cadastral map (N108 460812). Earthworks are to be seen north of Maitahi Stream, between the coast road at the seaward end of Leith Road and the low sea cliff. Ditch and bank defence encloses an area ca 80 m long and up to 45 m deep to the cliff edge. The square plan suggests European defences—or confirms the observations of the January 1865 *Taranaki Herald* correspondent.

PUKE TI

Puke Ti appears to have been occupied for a few weeks in March and April 1865, near the present junction of the main road and Perth Road. The name is sometimes given as Pukete, or Puketehe. A pa "Puki Ti" is marked on the NZMS 177 series cadastral map N108, map reference 477767 (and is described in Prickett 1983:20-21).

When Captain Carthew's Military Settlers moved south to relieve Captain Corbett they were first ordered to Puke Ti,

> ... where this Company will have to construct a Redoubt under the direction of Lieut Ferguson who will be instructed accordingly.
>
> The position of Puke Ti which is rather inland but on this side of Kaihihi, will be pointed out to the Officer Commanding by the D.A.Q.M. General, but it will be advisable to halt for the night at Tataraimaka, and March early next morning to Puke Ti, to get the ground marked out & the Camp pitched with the necessary Outlying Piquets before dark. (NP Garrison Quarter Master Letter Book, 19 Feb 1865)

No 4 Company was still at Tukitukipapa in mid-March, but early in April had reached Puke Ti (*Taranaki Herald* 8 Apr 1865). By this time work on the inland road from Tataraimaka to Stoney River was rapidly being completed, for which the new post was much more convenient.

On 23 April orders were given for Captain Carthew's company to join Colonel Warre at Warea (NP Garrison Quarter Master Letter Book). In June they were at Opunake (*Taranaki Herald* 24 Jun 1865). Puke Ti is listed as an occupied post in a report on the strength and distribution of troops on 31 May 1865 (AJHR 1865 A-4:63-64), but was probably already abandoned by this time.

No archaeological evidence has been found. A surveyor's field sketch which may relate to a military work at Puke Ti shows a rectangular fortification with flanking defence on the two long sides (Fieldbook O.7, p. 13, LINZ, New Plymouth). Exactly where this was is not clear.

CLOSING OFF THE NORTH

At the end of April 1865 military moves were made north and south of New Plymouth which were important for the prosecution of the war in Taranaki, and in the wider political history of New Zealand. The first was to Pukearuhe, an old Ngati Tama pa at the south end of Parininihi (White Cliffs), where a redoubt was thrown up to close off the route into the war zone from the north. The beach beneath the 300 m high White Cliffs was the last of three Maori routes into north Taranaki to be closed, after the others in autumn and spring 1864 (see Prickett 1996:23, 33).

A few days after the move to Pukearuhe Colonel Warre moved south to throw up strong redoubts at Warea and Opunake on the coast beyond Stoney River. This allowed land contact with General Cameron's troops campaigning out of Wanganui to the Waingongoro River, and

facilitated military action against centres of Maori resistance in forested areas west of Mt Taranaki.

Cameron insisted he gave no orders for the occupation of Pukearuhe or Opunake, and was angered by Warre and other officers communicating with Grey and government ministers behind his back. He wrote to Grey on 3 May:

> Since my arrival in Auckland on the 30th ultimo, I have read an account in the newspapers of Colonel Warre having occupied not only Te Namu, but also a point near the White Cliffs, about thirty miles, I believe, north of New Plymouth.
>
> I had not received your letter of the 26th April [in which Grey suggests that Warre occupy Opunake] when I left the Patea, and had therefore given no orders to Colonel Warre to occupy either of these points, and I am not aware by whose orders he has done so. (AJHR 1865 A-4:32)

Grey replied that he had no information regarding the occupation of Opunake or Pukearuhe, "... excepting a private note from Colonel Warre", and praising Warre's actions in the strongest terms:

> ... I believe that the two most important movements he has so skillfully and successfully made will go very far to bring to a close the war which has so long prevailed in the Taranaki district. (AJHR 1865 A-4:37)

The argument was eventually referred to London, on one occasion Cameron sending a vessel to Melbourne so that his despatches would arrive in England on the same mail as Grey's. The feud played a major part in Cameron's return to England in August.

Grey was less than straightforward. There is, for example, a letter to Atkinson, written some days before Cameron found out about the movement from the newspapers, in which he praises Colonel Warre for his action in occupying Pukearuhe (AJHR 1865 A-4:66). Warre was lucky to escape being cashiered, and earned a severe reprimand from the Commander in Chief (WO 0270.II).

PUKEARUHE REDOUBT

The immediate reason for the occupation of Pukearuhe is given in the *Taranaki Herald* of 29 April 1865.

> On Sunday last [23 April] a report was received through a native, who had come over from the enemy to warn the friendly natives, that the Ngatimaniapotos were expected down immediately by Wm. King's people. As it would have hindered the survey and occupation of the Waitara country, and interfered with any other movement, to have any considerable number of natives at Kaipikari, Colonel Warre with commendable promptitude, after consulting with the Minister for Colonial Defence, determined on taking possession of Pukearuhe, a position commanding the pass by the White Cliffs, and cutting off communication from the north. The Phoebe being opportunely in, was chartered to take 150 of the 70th and the Bushrangers down, and they accordingly embarked in the evening under command of Colonel Mulock, arriving off Pukearuhe early on Monday morning.

Because of deteriorating weather only part of the force was landed, without essential supplies

or commanding officer. The *Phoebe* went on to Onehunga. Those landed were Native Commissioner Robert Parris and two Maori, 35 Bushrangers under Captain Jonas and Lieutenant Free, and about 70 of the 70th under Captain Ralston (*Taranaki Herald* 29 Apr 1865). Stores included tents, two bags of biscuits and some salt pork (AJHR 1865 E-8).

That night a party of Maori came overland from New Plymouth, but were sent back to Mimi to obtain food from cultivations there (AJHR 1865 E-8). On Wednesday, 26 April, Parris returned to New Plymouth to make known the predicament of the men at Pukearuhe. Colonel Warre at once despatched the steam ship *Wonga Wonga* with supplies and reinforcements, which arrived on Friday morning. Captain Messenger, Lieutenant Clarke, Ensign Fookes, Surgeon Spence and 75 Military Settlers were added to the garrison and the Bushrangers withdrawn (*Taranaki Herald* 6 May 1865).

When Parris returned to Pukearuhe on 9 May he reported "a very fine redoubt" almost completed (AJHR 1865 E-8). On 31 May the garrison included Captain Ralston, two subalterns, three sergeants, five drummers and 61 rank and file, 70th Regiment; three subalterns, one staff officer, four sergeants, a drummer and 71 rank and file, T.M.S.; and two men of the 43rd Light Infantry (AJHR 1865 A-5:63-64).

A blockhouse was erected within the redoubt (Fig. 3). The successful tenderers at £340 were Messrs Burton and Kelly of New Plymouth. Because of a dispute over payment the tender document has been preserved (AD1 66/3019). The building was specified as including an upper floor 42 feet 6 inches by 18 feet, and a lower, 40 feet by 15 feet 6 inches. The dispute arose partly over the loss of building material with the wreck of the *Alexandra* at White Cliffs and the loss of the *Stuart*'s cargo at the Waitara River mouth. The blockhouse was completed at the end of September 1865 (AD1 65/2724).

Towards the end of August 1865 the 70th Regiment was withdrawn from Pukearuhe (AD31/24). Captain Messenger's No 5 Company Taranaki Military Settlers at the post were then made up of 100 men and four officers (AD1 65/2570). Soon after the troops' departure Major Baddeley

Fig. 3. Members of No 9 Company, Taranaki Military Settlers, gather for their rum ration outside the 1865-69 blockhouse at Pukearuhe, *ca* 1866. (Taranaki Museum.)

took command. Before the end of 1865 No 9 Company under Captain Page took over at the post (Fig. 3).

As an advanced frontier post Pukearuhe was subject to alarms as parties of Maori were seen in the district. In August 1865 there was daily skirmishing between the garrison and Mokau Maori who came down to compete for the cargo of the *Alexandra*. On 25 November a party of Ngati Maniapoto came along the beach from the north, exchanged shots on the beach below the redoubt, and later attempted to ambush Military Settlers who were cutting fern 200 yards south of the post (G16/7). In August 1866 Ensign Hursthouse was in command when 40-60 armed Maori passed through the district on their way north (G16/10).

Despite the remoteness, the garrison at Pukearuhe was reduced throughout 1866 and 1867. By September 1866 Captain Page was in command of 65 men (G16/10). At the end of the same month the departure for Patea of most remaining blockhouse garrisons in north Taranaki created a vacuum, filled by further reduction at Pukearuhe, 14 men from the post going to Okato, Tikorangi, Manganui and Mataitawa (AD1 66/4333).

By May 1867 a few men remained under the command of Lieutenant Gascoigne (AD1 67/1848). On 22 October 1867 the Taranaki Military Settlers were disbanded (Nankivell 1944:30), militia taking over at Pukearuhe under Gascoigne. Pukearuhe and Warea were now the only posts in Taranaki held strongly, and the only ones in advance of European settlement. Early in 1868 the remaining 25 men at both posts were withdrawn. At Pukearuhe three men took charge of the blockhouse (AD1 68/1353). In March the local command asked Wellington if one man might be kept on pay until the removal of ammunition and stores had been completed (AD1 68/793).

Reduction of the Pukearuhe garrison was accompanied by a general departure of Military Settlers from the district. In July 1867 one officer and 19 men were reported still cultivating land in the area (AD1 67/2634). When the garrison was withdrawn in 1868 the settlers unsuccessfully petitioned the Minister of Colonial Defence for its retention (AD1 68/3742). In October 1868 more settlers were reported leaving (AD1 68/3354). By the end of the year about 12 remained between Urenui and Pukearuhe (AD1 68/4943). In September an order was given that the blockhouses at Pukearuhe, Tikorangi and Okato be repaired, wells cleared out, ditches and banks repaired and fern cleared (AD1 68/3177). In November this was reported done although an earthquake had damaged the refurbished parapet and ditch at Pukearuhe (AD1 68/3851).

On 13 February 1869 Maori from the north killed the remaining Europeans at the post, comprising Lieutenant Gascoigne and his wife and three children, two other men, and the Reverend John Whiteley who arrived towards evening. They also burned down the blockhouse. An account is given in Cowan (1922-23 II:295-301). A manuscript, "Inquest Proceedings on those murdered at the White Cliffs", is held in the Taranaki Museum. The frontier was now drawn back 3 km to the Papatiki Stream at Waiiti and Pukearuhe was visited occasionally by patrols.

On 11 September 1872 Pukearuhe was re-occupied by Armed Constabulary from Waiiti Redoubt under Inspector Tuke (P1/19 Taranaki 1873). The redoubt was renewed and a new blockhouse built of single-storey barrack form (Figs 4 and 5). There were 38 A.C. at the post in 1873 (AJHR 1873 H-14:20), and the garrison was henceforth strongly maintained until the mid-1880s. As late as June 1884 there was one officer, four NCOs and 26 constables at the post (AJHR 1884 H-16:1). On 31 March 1885 the garrison stood at one officer, two NCOs and seven constables, with one NCO and nine men working on nearby road construction (AJHR 1885 H-4:7). The A.C. abandoned Pukearuhe on 26 November 1885 (P1 86/1092), after agreement with the King Movement opened up the King Country to European settlement

Fig. 4. Pukearuhe 1873, soon after it was reoccupied. Tents, but as yet no blockhouse, can be seen in the refurbished redoubt. (Thomas Good, Hocken Library, Dunedin.)

Fig. 5. Armed Constabulary, with piled arms and two coehorn mortars and shells, outside the 1872 redoubt and barrack building at Pukearuhe. (Alexander Turnbull Library, Wellington.)

Fig. 6. Pukearuhe during the Armed Constabulary period, 1872-85. (W.H. Collis photograph, Taranaki Museum.)

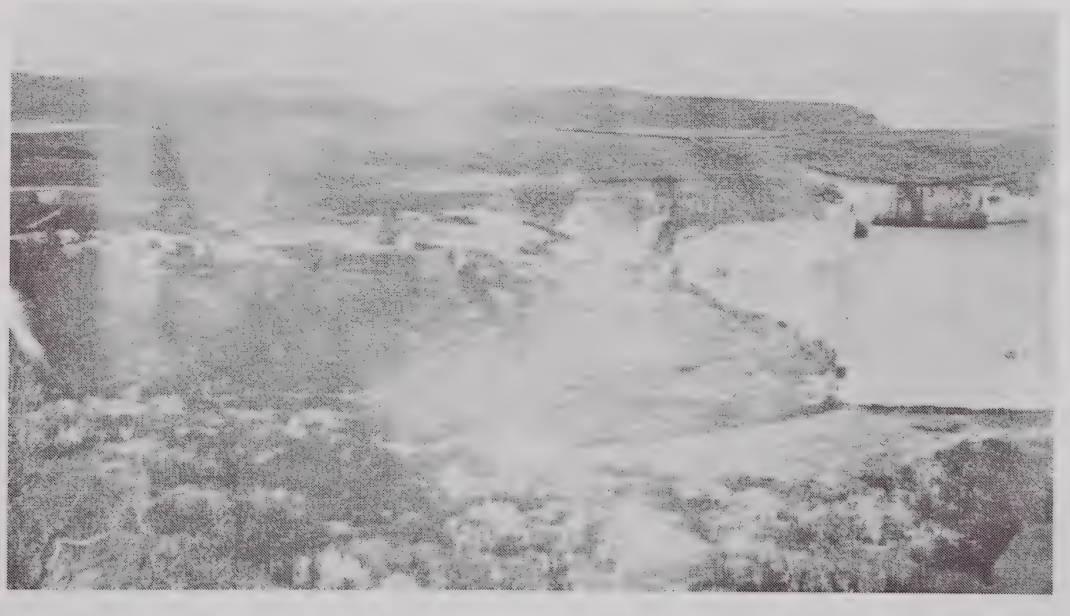

Fig. 7. Pukearuhe during the Armed Constabulary period showing the bastioned redoubt and settlement buildings. (Alexander Turnbull Library, Wellington.)

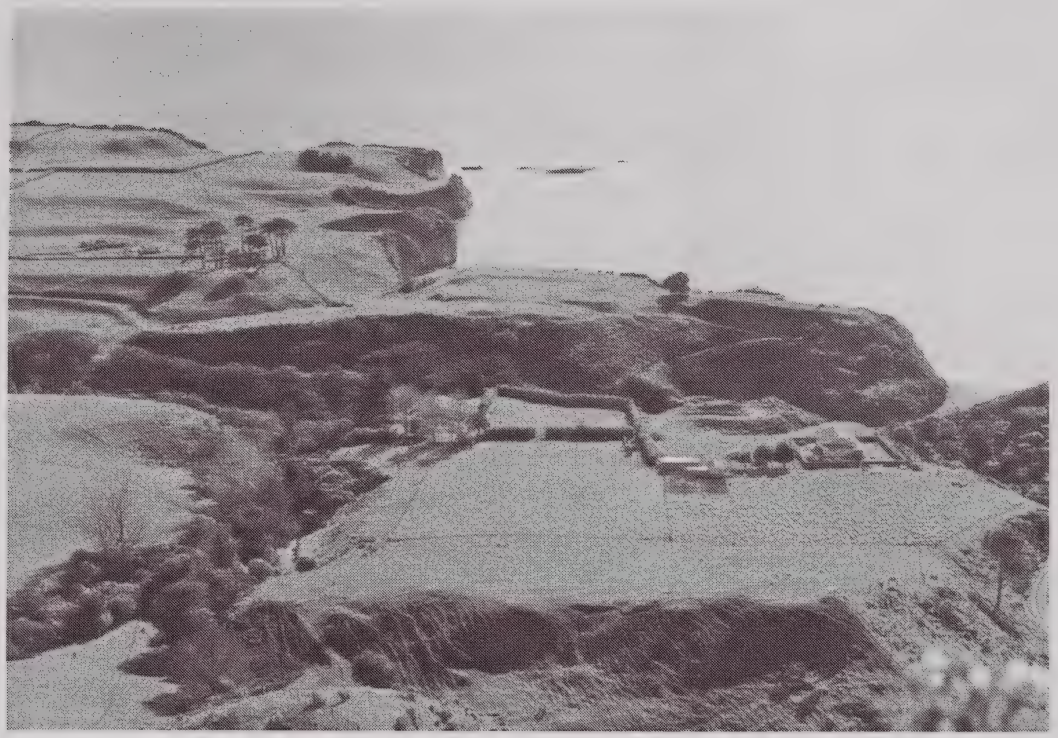

Fig. 8. Pukearuhe from the high ground to the east, 1968. Redoubt earthworks can be seen in the centre of the photograph, left of a pohutukawa tree. The old road runs down the hill to the stream mouth. The town of Clifton was laid out on the terrace beyond the trees and farm buildings, left. (Ken Gorbey.)

and removed the threat to Pakeha Taranaki's northern frontier.

During the Armed Constabulary period the Pukearuhe garrison was employed in road and bridge building, patrolling the nearby ranges, maintaining the fortification and quarters, and providing for themselves by extensive gardens on both sides of the Waikaramarama Stream. The settlement is pictured in Figures 6 and 7, and described by Brookes (1892:125-147).

The redoubt and settlement were at the north end of Pukearuhe Road on a steep-sided plateau between the Waikaramarama Stream and the sea, now an historic reserve in the ownership of the Department of Conservation (Fig. 8). The site had been a Ngati Tama pa, the old defences and terraces of which were altered for living quarters, especially in the A.C. period. The redoubt stood at the eastern corner of the central terrace to command the steep road to the beach and the way north.

The 1865 redoubt had five sides entirely flanked from three angles (Fig. 9). Entry was through one side and the north-west bastion. Inside was a two-storey loopholed blockhouse as outlined above. The A.C. rebuilt to essentially the same five-sided plan, but with greatly increased bastion defence (see Figs 4 and 7). The gateway was now in the middle of the seaward face. The new blockhouse was of single storey barrack form, without loopholes (Fig. 5).

In 1879 the redoubt was reduced in size (AJHR 1879 H-15:20). In the year ending 31 March 1882 a new ball-proof, loopholed blockhouse 18 feet square was built over the ditch at the north-west angle, as flanking defence for the west face (P1 82/1353). This stood until the

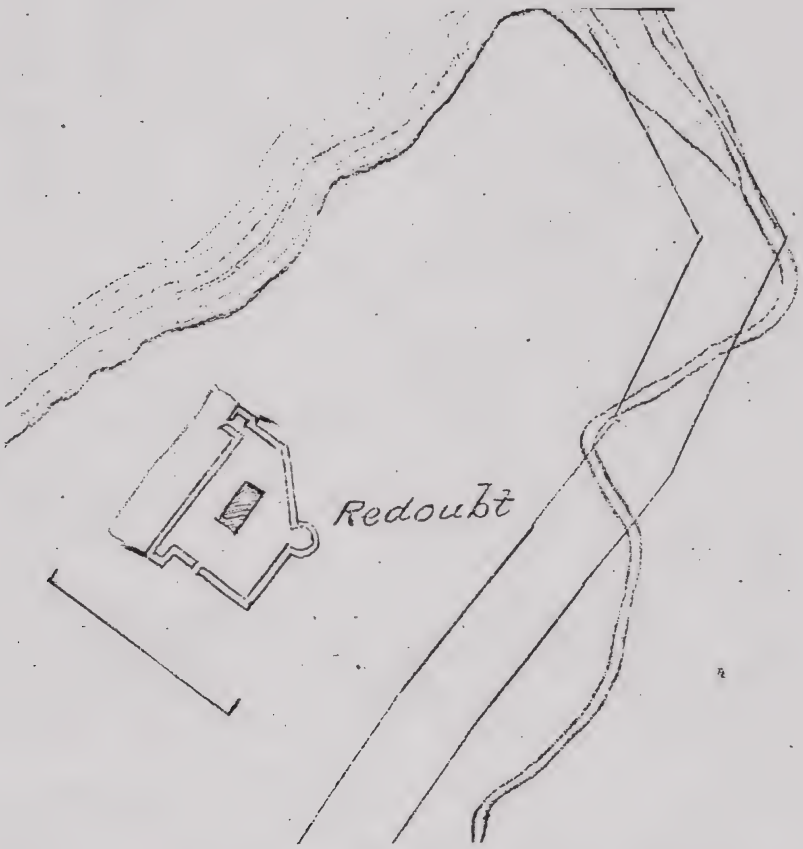

Fig. 9. Plan of Pukearuhe Redoubt, 1865-69. Taken from a map, "Town of Clifton Taranaki", September 1865, 3 chains to 1 inch (Taranaki Museum). North is to the top. In the Armed Constabulary period the work was more completely bastioned, and the only gate was at the centre of the north-east side. In 1879 the redoubt was reduced in size.

1930s enabling A.H. Messenger to draw the building for Cowan (1922-23 II:300). Archaeological evidence indicates a work ca 20 x 10-20 m in size. The north and east sides fall away to the old road; elsewhere cultivation has damaged the shallow remains of the defensive ditch.

The road to the beach is still in good order but for the beach end where it has slipped away. Between the central and northern terraces is a concrete hearth and other remains dating from the A.C. period, when there was here an astonishing bay-windowed villa built of raupo (Hammond 1979:17). Graves at the south end of the reserve post-date the military occupation. A monument to Whiteley and a stone marking the spot he was killed are a few metres from the redoubt. The Gilbert Track over the range into the Mimi River valley was largely destroyed when a gas pipeline was put through in the 1970s.

Excavations were carried out in 1968 on the route of the Kapuni gas line which crossed the southern terrace and two lower platforms. The report includes a map of Pukearuhe site (Lawrence and Prickett 1984).

TIKORANGI REDOUBT

After Pukeruhe was occupied two posts were established north of Waitara River to protect overland communication and prepare for settlement of the district. A newly raised volunteer force went to Tikorangi, and a Native Contingent under Captain Good to Urenui. A third post at Mimi River was planned but not established (AJHR 1865 A-4:55). Already in trouble over Opunake and White Cliffs, Colonel Warre was the subject of a further exchange between Grey and Cameron regarding Tikorangi (AJHR 1865 A-4:55-57).

The township and redoubt sites at Tikorangi were selected some days before the move to Pukearuhe, by Major Atkinson, at this time also Minister for Colonial Defence, along with the Native Commissioner, Superintendent and Provincial Surveyor (*Taranaki Herald* 22 Apr 1865). While Warre emphasised the military objective of maintaining communication with Pukearuhe (AJHR 1865 A-4:55), Atkinson sets out what was probably the more important consideration:

> It having been determined by the Government to form a Military Settlement near Tekorangi [sic] on the north of the Waitara river, consisting of one hundred and twenty men, and also two settlements of loyal Natives at Urenui and Mimi, I have the honor to request that you will be good enough to inform me whether you see any military objection to the plan being carried out immediately. (AJHR 1865 A-4:55)

Two companies of Taranaki Militia Volunteers were specially recruited for the Tikorangi settlement, and were promised land in the district according to conditions set out in a broadsheet, "Conditions upon which land will be given to settlers on the north of the Waitara" (AD31/1). Captains Armstrong and Jonas were in command of the companies, with overall command in the hands of Captain Stapp who was Adjutant to the local forces in Taranaki (65/4373 in AD1 66/430).

On 19 June 1865 the volunteers crossed the Waitara River and began work on a fortified position on the hill above their town site (*Taranaki Herald* 24 Jun 1865). Stapp soon reported that,

> ... on arrival at Tikorangi I erected a Stockade one Chain and a half square with two flanking angles at opposite corners and have also thrown up a Ditch inside. One side of the Stockade abuts on a nearly perpendicular Gully and I have had the Bush cleared away for a considerable space on the Outside and still continue to employ some of the men at the same work so that with the arrangements we make daily I consider we are perfectly secure. I have had a Bake House erected from which we are furnished with excellent Bread. I am also having a well sunk which has reached 84 feet with a prospect I hope of soon reaching a supply of water. (AD1 66/430)

The two companies moved into the stockade on 7 July (Jupp Diary 7 Jul 1865). A blockhouse was completed by the middle of October (AD1 66/430).

On 9 December 1865 the Tikorangi settlers were told officially that the men of one company would not have land in the district unless they accepted hill country sections (Jupp Diary 9 Dec 1865). It was suggested that the unlucky men might be given land south of Stoney River (Jupp Diary 11 Dec 1865; AD31/1). On 16 January 1866 the companies tossed for Tikorangi, No 1 Company being successful (Jupp Diary 16 Jan 1866). In February Captain Jonas' company shifted to Te Arei Redoubt, over the river to the south (Prickett 1996:36-37), and were later settled on land at Patea (AD31/9 "Crown Grants to be issued to the Forces at Patea").

The garrison at Tikorangi Redoubt was rapidly reduced as the men took up their land. When Military Settlers from throughout north Taranaki left for Patea in September 1866, Tikorangi was one of only four posts to retain a garrison (AD1 66/4333). The last men were withdrawn in February 1867 (TMS Memo Book, 13 Feb 1867). The fort served as a parade post for military settlers of the district, was maintained for future use, as in September 1868 when orders were given that the blockhouse be repaired, the well cleared out, fern cleared and ditches and banks made good (AD1 68/3177 in 68/3742).

During the 1869 White Cliffs scare the post was reoccupied and strengthened. On 15 February one corporal and four privates of Captain Kelly's Bushrangers at Sentry Hill were sent to occupy the blockhouse (TMV Order Book, 15 Feb 1869). The next day Ensign Lawson was ordered to take command, making up the garrison to 25 from settlers of the district (TMV Order Book, 16 Feb 1869). On 19 February it was reported that, "fires have been seen at Mokau", and that it was desirable that settlers sleep in the blockhouse that night. Lawson was instructed,

> ...to raise the parapet around the redoubt, have a draw bridge made from the material at hand, don't delay in strengthening the place at once, make it as strong as possible by widening and deepening the ditch. (TMS Memo Book, 13 Feb 1867)

On 25 November 1869 the garrison was reduced to one sergeant, a corporal and six privates (TMV Order Book, 23 Nov 1869). From 15 March 1870 five men were retained on half pay (TMV Order Book, 11 Mar 1870), and on 1 November the remaining man struck off pay (TMV Order Book, 30 Oct 1870). Tikorangi was then kept as a militia parade post. In March 1872 the blockhouse was repaired (AD1 72/224 in 72/239). Ten years later, orders were given to Captain Armstrong for the return of all government property issued to the Tikorangi Volunteers by 15 May 1882, this signalling the end of Tikorangi's role as a frontier post (TMV Letter Book 1881-1891, 20 Apr 1882).

The Tikorangi Redoubt site is on top of the hill at the south end of Ngatimaru Road (Fig. 10), and was in good order when I last saw it in 1997. The associated military township was laid out at the foot of the hill, 1.5 km from today's village at the corner of Ngatimaru Road and the Inland North Road. A January 1865 drawing of Te Arei Redoubt also shows the tents, huts and flagpole of Tikorangi Redoubt (Prickett 1996:37).

The historical record is not clear as to the nature of the defences at Tikorangi. Stapp's 1865 report of a stockade with ditch inside suggests an unusual work. Later emphasis is on a redoubt and blockhouse. There is no sign of a stockade in the only known picture of the post which dates from January 1866. Archaeological evidence (Fig. 11) suggests a rectangular redoubt of classic form (defence at two angles covering all sides), next to the "... nearly perpendicular gully" of Stapp's report, thus taking up the position apparently first occupied by the stockade. This work is ca 22 x 17.5 m measured along the top of the eroded banks, and so would fit within Stapp's "... one Chain and a half square" (30 x 30 m). An economical interpretation is that the present earthworks are of Stapp's ditch within the stockade, that the stockade was later removed and earthworks then developed as the sole defence.

The blockhouse is likely to have been within the redoubt or stockade defences. The building is said to survive today as part of a farmhouse on Ngatimaru Road. A 10 m square earthwork, 40 m east of the redoubt, surrounds a depression 3 m in diameter which probably marks the 1865 well. On the scarp edge to the south is surface evidence for the semi-subterranean soldiers' living huts of the period.

Fig. 10. Tikorangi Redoubt. Aerial view to south, 1975.

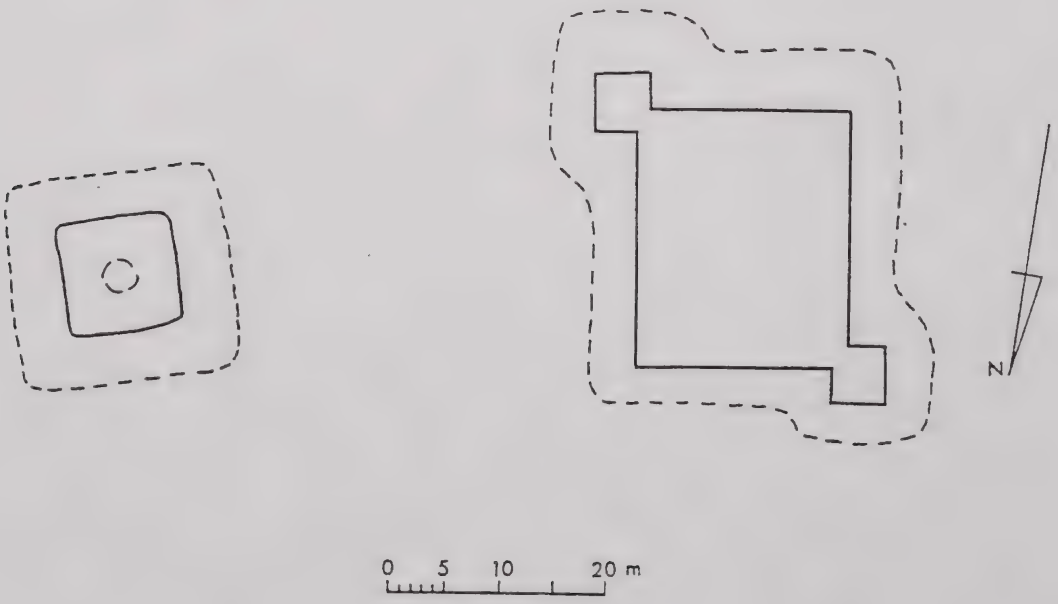

Fig. 11. Plan of Tikorangi Redoubt and outwork.

NO 2 COMPANY REDOUBT, ONAERO

The Tikorangi Block extended ca 5 km north from the Waitara River. The land beyond as far as the Mimi River was allocated to the Urenui Native Settlement (AD31/1). North of Mimi was the Military Settlers' Pukearuhe Block. In December 1865 the Chief Surveyor reported completion of the survey of 4000 acres at Tikorangi, but noted that 8000 acres were needed for the two companies (AD31/1). The miscalculation arose because half the block was unwanted, heavily bushed, steep hill country (*Taranaki Herald* 16 Dec 1865).

Seeing good land immediately to the north, which was apparently unoccupied, the men of No 2 Company under Captain Jonas moved on and built a redoubt 2 km west of the Onaero River. On 8 December they were ordered back to Tikorangi by the Minister for Colonial Defence.

> I have the hr to reqt you will be gd enuf [sic] to inform me by what authority Capt Jonas removed his Compy of Tikorangi Settlers nearer the Onairo [sic] River and there constructed a redoubt ... Col Lepr will give immediate orders for the return of Cap Jonas' compy of Mila to Tikorangi. Before leaving their present camp they are to level any earthworks that they may have constructed. (AD31/1)

Later, as we have seen, the Tikorangi Block was won on the toss of a coin by Captain Armstrong's No 1 Company, No 2 Company departing, ultimately to the Patea district. Ironically, only a few months later, men of No 6 Company, T.M.S., were settled on land north of Tikorangi as there was not enough for them beyond Mimi (AD6/6 66/1755/1).

Fig. 12. No 2 Company redoubt, Onaero. Aerial view to north, 1975.

This unusual episode has left field evidence of a redoubt south of the Inland North Road, and 100 m west of the present Waiau Road (Fig. 12). The work is ca 22 x 24 m, with what appears to have been flanking defence at two angles covering all four sides. The earthworks have been greatly damaged, presumably initially by the destruction ordered in December 1865. There has also been stock damage. Three graves were noted within the old earthworks when the site was visited in the 1970s.

URENUI REDOUBT

The post at Urenui, like that at Tikorangi, dates from winter 1865, when it was put up to secure overland communication with Pukearuhe. Urenui was to be a settlement of "loyal Natives" (AJHR 1865 A-4:55). A work capable of holding 80 men was built in July by Captain Thomas Good and the Maori force (AD35/12), high on the left bank of the Urenui River on the site of an old pa called Pihanga. In early reports the redoubt often appears as 'Pihanga' or 'Te Pihanga' (sometimes 'Pehanga' or 'Pehangi').

Urenui's status as a Maori settlement was shortlived: by August 1866 it was decided to settle men of No 6 Company, T.M.S., who had missed out at Pukearuhe, between the Urenui and Onaero Rivers, the men being ordered to parade at Captain Messenger's house in Urenui on 3 January 1867, to select their town and rural sections (TMS Memo Book, 28 Dec 1866). The Native Contingent was by this time also settled on land in the district (AD1 67/2781).

Urenui Redoubt was held for many years by various Maori and European forces, at first Maori under Captain Good. As early as November 1865, 50 Tikorangi Volunteers were despatched to Urenui and Pukearuhe following a scare in the Pukearuhe district (G16/7). After the February 1869 raid on Pukearuhe, Cornet Bayly and 13 Taranaki Cavalry Volunteers were sent to Urenui to place themselves under Captain Good (TMV Order Book, 15 Feb 1869). A few days later Captain Messenger took charge at the post (TMS Memo Book, 19 Feb 1869).

In 1869 and 1870 Urenui was one of the strongest posts in Taranaki, and a key overland link to the Papatiki Stream frontier. The garrison included militia, Armed Constabulary and Native Contingent. In November 1869 the garrison was reduced to one captain, a sergeant, corporal and 18 privates (TMV Order Book, 23 Nov 1869). On 9 May 1870 Good was ordered,

> From & after 12th Inst. the detachment stationed at Urenui will be reduced to 1 Capt, 1 sergt, 1 Corpl, 15 Privates, 2 ferrymen at Mimi, 1 scout at Kipikeri [sic], 1 scout at Tupari, 1 ferryman at Urenui. (TMV Order Book)

Maori scouts at Tupari and Kaipikari were struck off pay in November 1870 (TMV Order Book, 30 Oct 1870).

The 1870 annual report of the Armed Constabulary puts the garrison at three sergeants and 18 constables, plus one captain, a corporal and six privates "Local Militia", and ten "Natives" (AJHR 1870 D-7:10). In 1871 there were two constables at Urenui (AJHR 1871 G-5:18), and as late as September 1872, six militia and 12 Maori under Captain Good (AD1 72/1187). A.C. remained at two constables until 1882 (AJHR 1882 H-14:11), and one man until final abandonment of the post in 1884 or 1885 (AJHR 1884 H-1:7). The redoubt was occupied for 20 years.

In December 1868 repairs to the fort cost £25 (AD6/13 68/613/1). In September 1872 approval was given for construction of two bastions, to "... make the redoubt almost impregnable, at present there are no angles or bastions" (AD1 72/1187).

An ink sketch from an 1865 surveyor's notebook shows Urenui before flanking defence was added, with the partly stockaded work enclosing two huts and a flagpole (Fig. 13). Figure 14

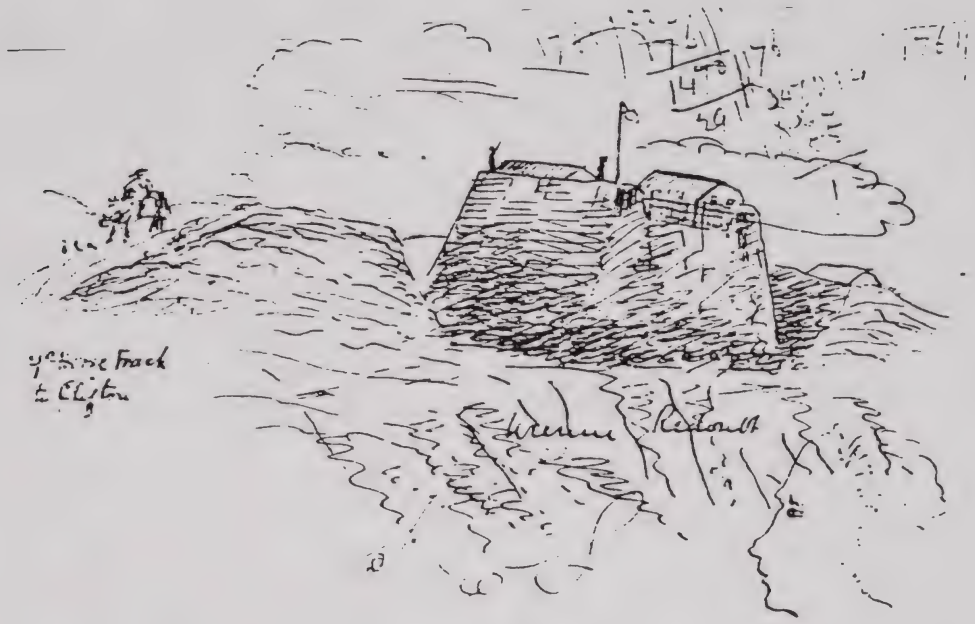

Fig. 13. Urenui Redoubt, December 1865. An ink sketch by S. Percy Smith from his surveyor's fieldbook. The caption at left states, "Horse Track to Clifton". (D.R. Rinckes.)

Fig. 14. "Urenui Redoubt held by Friendly Maoris under Captn Good", W.B. Messenger. (Alexander Turnbull Library, Wellington.)

dates from after September 1872 since a projecting bastion is shown at the northern corner. Paintings by Thomas or Fanny Good, held in the Taranaki Museum, show a bridge across the ditch to a narrow gate. Inside are buildings and a flagpole. The projecting sentry box is loopholed for defence.

Urenui Redoubt was high on the left bank of the Urenui river commanding a wide view northward, but a restricted view south and west owing to rising ground behind the post. Buist (1964:56) published a plan of the remains in 1961. The work was ca 24 m across the face overlooking the river, and extended 21 m to the south side which was 21 m long. A farm road has damaged the north-west side. In 1975 the exterior height of the wall was 2.8 m, while the interior height was 0.5–1 m. The wall was then in good order, but a vegetable garden had destroyed any archaeological remains within the earthworks.

Buist (1964:71) also notes: "Military redoubt on terrace edge near coast east of Onaero River mouth". This site is 1 km west of Urenui Redoubt, at trig 10922 which is 42 m above sea level (Fig. 15). An off-square platform 21–17.5 m long and 14-12.5 m wide overlooks a wide area south and west. Charcoal and oven stones suggest Maori occupation, while pieces of glass confirm an historical date. An earth bank is indicated by a raised platform margin. The site overlooks ground—and the road north of Waitara—not seen from nearby Urenui Redoubt. This may not be a military site despite appearances. No historical reference has been found.

Other sites in the Urenui district deserve comment. The ferry was located where the present walking bridge crosses the river to the monument at the birthplace of Te Rangi Hiroa (Sir Peter Buck). An Arden watercolour of the ferry is held in the Taranaki Museum. In 1872 the first bridge, of puriri and matai piles and rimu upper part and decking, was built across the river here (P1 72/1031).

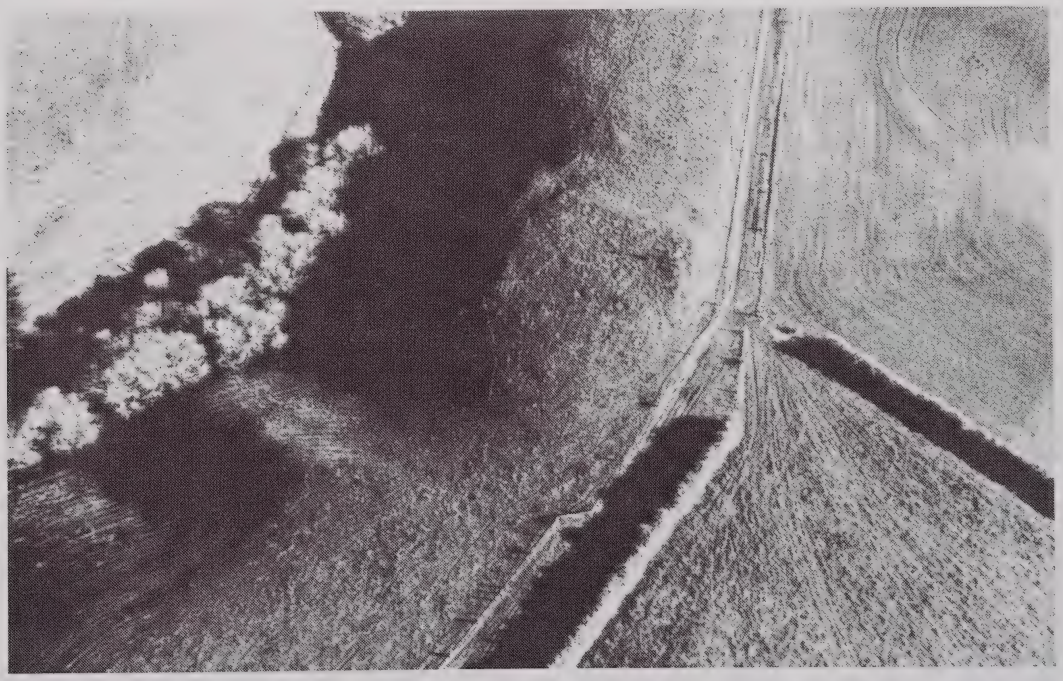

Fig. 15. Remains of a possible European or allied Maori fortification between the Urenui and Onaero Rivers. Aerial view to the east.

Kaipikari and Tupari, mentioned above as having Maori scouts in 1870, were Maori villages on high ground at the edge of hill country south and north of Urenui River. Kaipikari was just off the present Kaipikari Road at the top of the hill as the road rises off the coastal terrace. The trig Kaipikari, 161 m above sea level, locates the site. The settlement was attacked by the 43rd and 70th Regiments and allied Maori under Colonel Warre in December 1864. The *Taranaki Herald* (3 Dec 1864) reported, "... a formidable stockade, and half a mile of rifle-pits recently constructed. The enemy on the approach of the attacking forces fled."

Tupari overlooked the coastal terrace north of Urenui River. Surviving defences comprise scarps only (Buist 1964:65). In 1872 the settlement had a population of 61 under Pake, Tio and Tepatu (CD72/1152).

BEYOND STONEY RIVER

When Colonel Warre ordered British troops over Hangatahua (Stoney River) at the end of April 1865, he was encouraged by Grey, but without orders from General Cameron who was his commanding officer. The feud that resulted has been outlined in the section on Pukearuhe Redoubt. Warre's occupation of Warea and Opunake enabled him to take the war to rear Maori bases and kainga in the forest west of Mt Taranaki, and it secured the district north of Stoney River, soon to be settled by Pakeha farmers.

WAREA REDOUBT

Warea Redoubt was thrown up on 28 April 1865 by a force under Colonel F.H. Synge, 43rd Regiment, following an ambush of eight men of the 43rd and Taranaki Mounted Volunteers south of Stoney River on 22 April (*Taranaki Herald* 29 April 1865). Supervision of the layout and construction was by Deputy Assistant Quarter Master General in New Plymouth, Lieutenant C.M. Clarke, 57th Regiment (NP Garrison Quarter Master Letter Book, 8 May 1865). When some of the garrison moved on to Opunake on May 2 Synge remained in command of a garrison of 170 men.

On 31 May 1865 the Warea garrison consisted of one field officer, two captains, eight subalterns, one staff, ten sergeants, eight drummers and 186 rank and file, 43rd Regiment, along with seven rank and file Taranaki Militia (probably Mounted Volunteers), and one captain, one sergeant and 15 men of the Commissariat and Transport Corps (AJHR 1865 A-5:63-64). With the addition of some artillerymen and an engineer it was much the same on 1 July (WO O270 II:434).

The forested district inland of Warea Redoubt saw some of the last fighting of the Second Taranaki War. On 13 June 1865 Colonel Warre took out a force of 43rd and 70th Regiments and Bushrangers to attack Maori villages inland of the redoubt (WO 0270 II). Another skirmish took place on 28 July when Major T.E. Holmes was in command at the post (WO 0270 I:App. XXX). On 2 August 1865 a strong force marched from the redoubt under Lieutenant Colonel Colvile, once more to attack inland settlements (WO 0270 II).

Warea was still held by 170 of the 43rd on 29 January 1866, when Major General Chute arrived on his return to the Patea district after marching through the bush inland of Mt Taranaki (AJHR 1866 A-1:88-90; and see Anon 1866:27). At Warea Chute took the opportunity once more to attack inland villages.

When the 43rd sailed for England in March 1866 (Levinge 1868:292) it was replaced in Taranaki by the 50th, a detachment of which was posted to Warea (Fyler 1895:286). The redoubt was under the command of Lieutenant Colonel F.G. Hamley from 24 March to the end of June (AJHR 1867 A-1:23). Hamley shifted to New Plymouth when he became

Fig. 16. Warea Redoubt. Aerial view to the south, 1975.

commanding officer in Taranaki in early July (NP Garrison Order Book 4 Jul 1866), leaving Captain Clarke, who had originally laid out the work, in charge at Warea (AJHR 1867 A-1:23). At the end of August there were still 145 rank and file at the redoubt (AJHR 1867 A-1:13). The 50th stayed on until 3 May 1867 when they were withdrawn from Stoney River, Warea and Opunake before leaving New Zealand.

Warea was then held by 25 militia under Lieutenant Charles Messenger (*Taranaki Herald* 4 May 1867). In September 1867 70 men of the Patea force under Lieutenant Colonel Thomas McDonnell marched along the coast in a show of strength. When they returned south, Ensign von Rotter and 25 men were left to take over from the militia at Warea (AJHR 1867 A-21:1-2). At the beginning of 1868 Warea was abandoned, virtually all north Taranaki military forces now being concentrated in New Plymouth (*Taranaki Herald* 1 Feb 1868).

In February 1868 an Armed Constabulary force was raised in Taranaki. Twenty-four men were sworn in and started for Warea on the 8th, probably under the command of Captain W. Newland (*Taranaki Herald* 8 Feb 1868). A month later Warea was abandoned for the last time when the A.C. returned north to establish headquarters at Sentry Hill (*Taranaki Herald* 8 Mar 1868).

Warea Redoubt was on the coast 5 km north of Cape Egmont, at the edge of a low terrace above the beach on the north side of the Teikaparua River (Fig. 16). Until the present main road was put through in the 1880s this was on the main route south, along the coast. In many places the old road remains easy to follow, especially where it is still legal road, as next to the

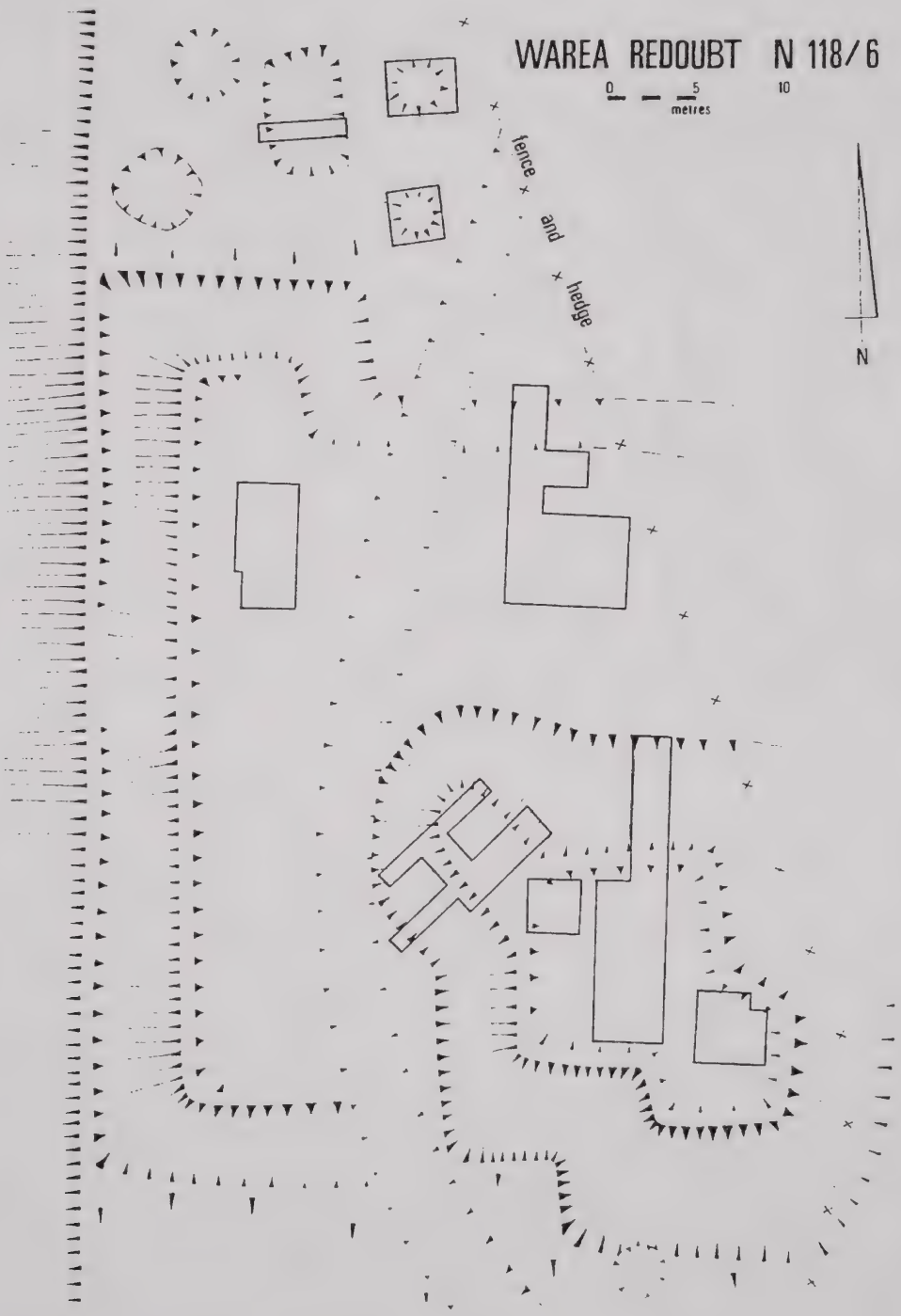

Fig. 17. Plan showing 1865 and 1867 redoubts at Warea, and areas excavated in 1978 (see Prickett 1994b).

redoubt. The earthworks of the old redoubt and associated camp were still in good order in 1997.

An earthwork 10 m square has 7 m square flanking defence at the south-east angle and a projecting platform at the opposite corner to flank the other two sides (Fig. 17). North and west are the remains of an earlier redoubt 40 x 30 m in size. The bigger work dates from 1865-67 when there was a substantial garrison of imperial troops at Warea. The smaller, which makes use of a corner of the earlier work, dates from May 1867. The history of these changes and a full description of related archaeological evidence are given in an account of 1978 excavations at the site (Prickett 1994b).

OPUNAKE REDOUBT

Although there was dispute as to who issued orders to Warre for his movements to Pukearuhe and Opunake, there can be no doubt that General Cameron had previously discussed establishing a post at Opunake.

> Before leaving the Wanganui districts, the Lieutenant-General had informed his Excellency that though he did not consider it advisable to establish more posts northwards from the Waingongoro, a post might be established from the Taranaki side at Te Namu, about fifteen miles southwards from "Stony River". (WO 0270.1:137)

The Opunake force sailed from New Plymouth at midnight on Friday 28 April, on board the steam ship *Wanganui*.

> The Wanganui having on board Colonel Warre, C.B., Major Russell, Garrison Adjutant, Mr Parris, Assistant Native Secretary, (with a canoe and five natives – the canoe hoisted on board) Captain Gibson, Harbor Master, with a surf boat and life boat (in tow) and crews – Capt. Cay, Lieut. Bally, Ensign Howard and 85 men of the 70th Regt., Captain Stapp, Ensign Lawson and 26 Bushrangers, 3 Artillery men and a $5^1/_2$ inch mortar, Lieut. Ferguson and 2 men of the Royal Engineers, and Lieut. McMahon 14th Regiment, Acting Deputy Assistant Commissary General, left the roadstead at midnight, and steaming at half speed was off Harriet Bay at dawn on Saturday morning, the weather being fine and the sea calm as a mill pond. (*Taranaki Herald* 6 May 1865)

The troops landed unopposed at Opunake. A stockade on top of the cliffs south of the bay was taken, the tents pitched in and around the stockade, and Lieut. Ferguson marked out the lines for a redoubt (*Taranaki Herald* 6 May 1865; Fig. 18). A watercolour by Colonel Warre probably dates from this day since it shows tents in front of a palisade and no sign of a redoubt ("Camp Opunake", Warre Sketchbook, Alexander Turnbull Library, Wellington). Warre returned to New Plymouth by sea the same night, leaving 120 men at Opunake under Captain Cay (NP Garrison Quarter Master Letter Book, 8 May 1865).

Reinforcements marched south from Warea Redoubt on 2 May, Colonel Warre in command of 210 43rd Light Infantry, 35 Taranaki Mounted Volunteers, 41 Bushrangers and 77 Taranaki Military Settlers. Warre and the Mounted Volunteers reached the new redoubt at 3 p.m. on the 2nd, the rest arriving the following day (NP Garrison Quarter Master Letter Book, 8 May 1865). In the next few days the redoubt was rapidly completed despite the fact that, according to Warre, "... Mr Ferguson chooses to make the parapets so much too thick causing so much extra work" (Warre Journal 5 May 1865).

Warre rode north again on 7 May, reaching New Plymouth in 12 hours. A strong garrison

Table 1. Summary of the May 1865 garrison at Opunake (NP Garrison Quarter Master Letter Book, 8 May 1865).

	Officers	Sergts	Drummers	Rank & File
Commissariat & Transport Corps		1		13
Royal Artillery		1		8
Royal Engineers				2
43rd Regiment	10	12	6	180
70th Regiment	3	4	1	78
Mounted Volunteers	1	1		10
Military Settlers	3	3	2	66
	17	22	9	357

remained at Opunake (Table 1).

On 7 June Colonel Warre led a force of 43rd and 70th Regiments, Mounted Volunteers and Bushrangers, from Opunake to Waingongoro, the northernmost outpost of General Cameron's campaign out of Wanganui (AJHR 1865 A-5:55). This was the first land contact with European forces outside the north Taranaki area since fighting began more than five years previously, preceding by eight months General Chute's well-known march inland of Mt Egmont.

On 15 February 1866 more than 300 men under Lieutenant Colonel Synge marched out of Opunake to attack Maori at the kainga, Ngapuketuranga, four miles (6.5 km) away. Four of the attacking force were wounded in the affray (G16/11). On 21 February Captain Horan went to Witiora, 10 miles (16 km) north, where he was joined by a force from Warea under Captain Talbot. Two days were spent destroying cultivations and burning villages in the area (G16/11). Clark (1896) gives an account of activities of the 43rd Regiment at Opunake.

The 50th took over in February 1866 (Clark 1896:246; Fyler 1895:286), and on 20 August there were still 103 rank and file at the post (AJHR 1867 A-1:13). In May 1867 the 50th left Opunake before returning to England. The redoubt was then given over to Wiremu Kingi Matakatea's people, to the great indignation of the Taranaki press (*Taranaki Herald* 13 Apr, 4 and 11 May 1867).

In the period after the Second Taranaki War Opunake lay outside the area of European control; but there was nonetheless some European settlement. Flax mills were established in the early 1870s, and Native Police under Mr Patricio Wilson occupied a post at Te Namu at the Otahi Stream north of the bay (NS71/472 in AD1 71/1338).

In March 1875 Opunake entered its second period of military occupation when 25 Armed Constabulary were directed there to assist the Native Police put down unrest among local people. They landed from the steamship *Napier* on 2 March, and set up camp at Te Namu (*Taranaki Herald* 3 Mar 1875).

In April 1879 the A.C. under Captain Tuke shifted to the site of the old redoubt on the south side of Opunake Bay (AJHR 1881 H-18:2).

> A large amount of work was done at that time in removing buildings, stores, &c. Since the arrival of detachments from depot the men have been constantly employed

> completing the buildings removed from the old site, building a weatherboard store, men's and cook houses, chimneys to library and officer's quarters, and stone oven, 8 feet by 6 feet, for baking bread, &c; and all other necessary works have been pushed on as fast as possible. (AJHR 1879 H-15:21)

The measurements of the reworked redoubt are given as "120 by 130 feet".

In 1880 and 1881 there was a considerable build-up of A.C. and volunteer forces in the course of the Parihaka Campaign. Many of the men landed at Opunake Bay, which was the headquarters camp for much of the campaign (AJHR 1879 H-15:21). Major Goring was in charge at Opunake for a time, making way for Colonel Roberts when headquarters were established. Other officers in charge of the Opunake station were Captains Morrison and Capel, and F.J.W. Gascoyne who was at the post from the end of 1884 to January 1887 (Maxwell 1935:79; Gascoyne 1916:124).

In 1881 it was reported that the redoubt at Opunake, "... could be held by a handful of men occupying the bullet-proof, loop-holed blockhouse recently erected at one of the angles" (AJHR 1881 H-18:2). On 31 March that year the A.C. garrison totalled 54 men (AJHR 1881 H-18:12). As late as 1885 numbers were much the same, with 18 men at the camp and 31 making up a road-making party (AJHR 1885 H-4:7). A year later A.C. numbers in the district stood at 51 (AJHR 1886 H-18:7). The 'old force' was disbanded on 1 September 1886 (AJHR 1887 H-5:1), and Opunake Redoubt abandoned probably early in 1887 (Gascoyne 1916:130).

Fig. 18. Opunake Redoubt, 24 October 1867. (Nelson Carrington, Fieldbook I.24, LINZ, New Plymouth.)

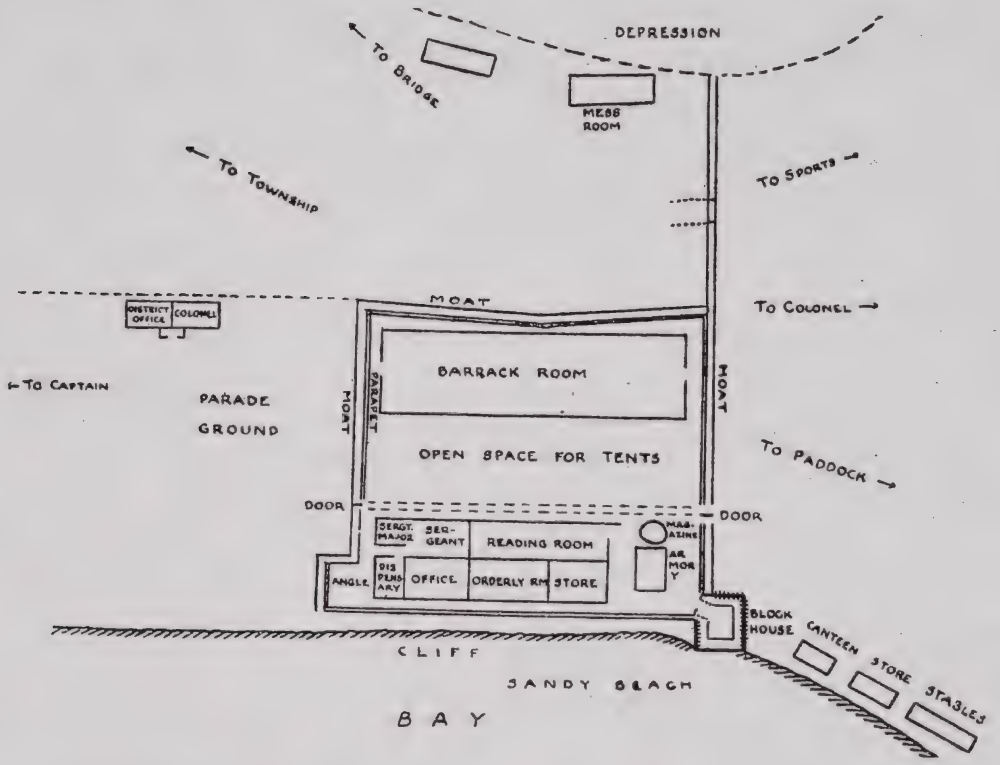

Fig. 19. Opunake Redoubt in the 1880s (Maxwell 1935:90).

Fig. 20. "Opunake Redoubt 1879". (Taranaki Museum).

Fig. 21. Armed Constabulary redoubt, Opunake, 1881, G. Sherriff. (Alexander Turnbull Library, Wellington; from Cowan 1922-23 II: 482.)

Fig. 22. Opunake Redoubt in the centre below the double wheel tracks. Aerial view to the north-west, 1975.

The 1865 redoubt made use of the cliff to the beach for one side, the other three sides being covered by flanking defence at one end (Fig. 18). In 1879 the Armed Constabulary threw up a parapet above the cliff, with flanking defence on the inland side removed in favour of the whole side being slightly angled to the centre (Figs 19 and 21). An 1879 photograph shows the refurbished redoubt a year before the Parihaka Campaign (Fig. 20). An 1881 drawing by Sherriff shows a loopholed blockhouse to have replaced the earth bastion left of the main gate (Fig. 21).

Opunake Redoubt was at the south end of Opunake Bay, between Layard St and the cliff above the power station. The earthworks were largely destroyed some time before 1935 (Maxwell 1935:85). The ditch of the 30 m square redoubt could still be traced in 1997, although it was not as clear as when I first visited in 1975 (Fig. 22).

TAKING UP THE LAND

Blockhouses were erected to secure land taken up by military settlers. Many were at town sites where each settler had an urban section separate from his rural land. North of New Plymouth, townships were laid out at Pukearuhe (Clifton), Tikorangi, Manganui, Huirangi, Mataitawa and Manutahi (Lepperton). South were Tuahukino (Koru), Ahu Ahu and Okato. Only Lepperton and Okato have survived as townships. Blockhouses at Waitara (Prickett 1994a:22), Huirangi and Mataitawa (Prickett 1996:38, 41-43) I have dealt with elsewhere. Pukearuhe and Tikorangi are described above in the history of campaigning. Te Arei Blockhouse dates from the 1869 raid on Pukearuhe and is introduced below.

OKATO BLOCKHOUSE

In January 1865 Colonel Warre and Major Atkinson inspected the district north of Stoney River for township sites (*Taranaki Herald* 21 Jan 1865). Atkinson returned the following month to fix the location of a military post and settlement (*Taranaki Herald* 25 Feb 1865). In winter 1865 the Military Settlers to be settled at Okato were attached to the field force campaigning out of Warea and Opunake. In early September they were ordered from Stoney River Redoubt to the new town site, where Colonel Warre had decided on yet another location for the blockhouse, to better command the country (AD1 65/2724).

> Capt Carthew is requested to use every available man of his Det. in clearing a road from his present post one mile and a half inland in a straight line where there is an old "Pah" in the vicinity of which his Bhouse is to be erected. (TMS Memo Book, 4 Sep 1865)

Work began at once on a blockhouse, carpenters from among the Military Settlers being employed to finish the building before 31 October at the cost of £40 (AD1 65/2724). On 20 September the men were ordered to camp within the redoubt when it was ready and to continue work on the blockhouse (TMS Memo Book, 30 Sep 1865). The building was reported completed on 17 October (AD1 66/430).

Captain Carthew's men were struck off pay and placed on their land early in 1866 (*Taranaki Herald* 6 Jan 1866). On 26 September that year the remaining non-commissioned officer was ordered to lock up the post and proceed to New Plymouth en route for Patea (TMS Memo Book). Men were then sent to Okato from Pukearuhe (AD1 66/4333). The post appears to have been abandoned soon after this. It was briefly reoccupied in September 1867, after a minor scare at the southern frontier: four men were to be in the blockhouse at night and two on guard in the redoubt during the day, these men probably being drawn from settlers in the district (TMS Memo Book, 23 Sep 1867).

Repairs on the blockhouse and redoubt were carried out in December 1868 by Armed Constabulary and a party of newly enrolled Bushrangers under Captain Kelly (AD1 69/2080). In February 1869, following the attack on Pukearuhe, a sergeant and four men of the Bushrangers were sent to Okato (TMV Order Book, 15 Feb 1869). The next day Ensign Curtis was ordered there, to make the garrison up to 25 from settlers of the district (TMV Order Book, 16 Feb 1869). Throughout the 1870s Okato was held by a small A.C. garrison, the post being abandoned only after Parihaka was taken in 1881.

At first a blockhouse was built, within a redoubt big enough to hold it and tents for an entire T.M.S. company. In December 1868 the Bushrangers reported that they, "commenced the redoubt" on the 12th, the day after arriving at Okato (AD1 69/2080). However, in the Colonial Defence office report of 1869 the post at Okato is listed as a "Blockhouse and Stockade", capable of holding 30 men, with one officers, one guard and one store room (AD35/12). Repairs to the blockhouse in March 1872 cost £3/5- (AD1 72/224 in 72/239).

The post was described by Sergeant Lister, A.C., in September 1872.

> Okato is a small redoubt which would accommodate about 30 men, surrounded by palisading of stout timber with no flanking angles. The block House inside is a weather Board building not bullet proof nor lined. It is in the form of a T having one large room and three smaller ones officers quarters, storeroom & Guard room it occupys an old Moarie [sic] position on the top of a hill and commands a view of the country for about four miles round. (CD72/1156)

Fig. 23. The Okato Blockhouse occupied the square platform behind the house on top of the hill, in the centre of this 1975 aerial photograph. The view is to the south.

In 1879 the post was again altered.

> At Okato the redoubt has been rebuilt where required, and kept in repair, and is now undergoing considerable alteration and improvement. (AJHR 1879 H-15:20)

The Okato Blockhouse and redoubt were on top of the prominent hill inland of the present township (Fig. 23). The trig "Okato" (432 feet – 131.7 m) is at the north-east corner of the earthworks. Terraces on the side of the hill probably originate with the older pa on the site, modified to provide for soldiers' huts and other facilities.

An aerial photograph of 22 May 1950 shows the site before the present house and tennis court were put on top of the hill. Platforms encircle the hill below a square earthwork. In 1975 the redoubt walls were in good order, but the ground inside had been largely disturbed. The earthworks still appeared to be in good order in 1997.

Archaeological evidence indicates a rectangular redoubt 15 x 11 m with massive earth walls (Fig 24). There is strong circular flanking defence at the northern angle. A gap of 2.6 m in the north-west wall indicates the gateway. The blockhouse was presumably within the redoubt.

At an early stage the work appears to have been larger than shown by present field evidence. Later it may have included redoubt and stockade defences, perhaps like the first position at Tikorangi. At the end of its life indications are for a small earthwork defence.

TUAHUKINO BLOCKHOUSE

Tuahukino Blockhouse was situated at the Koru town site 3 km up Koru Road from the main South Road. It dates from April 1865 when Captain McKellar's company of Military Settlers was sent there from Timaru Redoubt (NP Garrison Quarter Master Letter Book, 18 Apr 1865; see Prickett 1996:44). The blockhouse was built by the firm of Burton and Kelly, which tendered £165 for the job on 25 May 1865 (AD1 66/3019). It was completed early in July. Except for a corporal and four privates, Military Settlers were struck off pay on 30 June 1865 and settled on their land (AD6/4 65/4118).

In September 1866 the non-commissioned officer at Tuahukino was ordered to lock up the blockhouse and go to town en route for Patea (TMS Memo Book, 26 Sep 1866). Tuahukino was not re-occupied. In 1869 the building, with accommodation for 25 men, one officers' and one store room was reported in good repair (AD35/12). As late as January 1872 the Tuahukino Blockhouse was retained for further use (AD1 72/239). It is not known when it was finally given up. The post probably comprised a barrack building within a stockade, like that at Mataitawa (pictured in Prickett 1996:43). No archaeological evidence has been found.

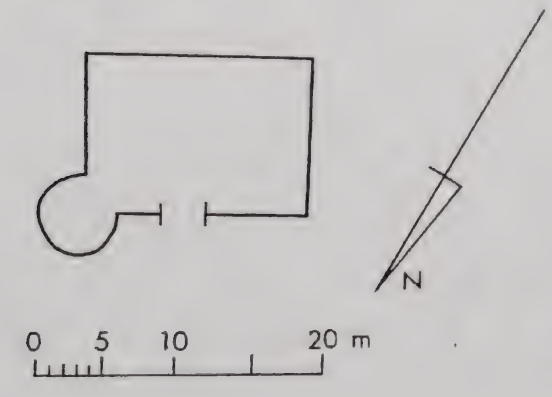

Fig. 24. Plan of earthworks at Okato Blockhouse site, 1975.

AHU AHU BLOCKHOUSE

Ahu Ahu Blockhouse was at the town site of that name at the junction of South and Ahu Ahu roads. The site was chosen by Colonel Warre in April 1865 (Warre Journal 7 Apr 1865). On 9 August 1865 the Lower Kaitake Blockhouse was ordered removed to Ahu Ahu for re-erection without delay (AD6/5 65/131/1; and see Prickett 1996:28). In early September the blockhouse was finished but for palisading (AD1 65/4299). On 17 October it was reported complete (AD1 66/430).

Military Settlers were placed on land at Ahu Ahu before the blockhouse was erected, and by 30 June 1865 were struck off pay except for one corporal and four privates who were to make up a garrison (AD6/4 65/4118). In September 1866 the non-commissioned officer at Ahu Ahu was ordered to lock up the blockhouse and leave for town, and ultimately, Patea. Ahu Ahu was not re-occupied, being maintained for some years only as a parade post for local militia. In the 1869 Colonial Defence Office report the blockhouse is described as having accommodation for 35 men, with one officers' and one store room (AD35/12). It was sold by auction on 13 January 1872 (AD1 72/239).

The Ahu Ahu Blockhouse was a stockaded fort like Tuahukino. The location is given on the relevant Block Sheet (Cape III (14/5), LINZ, New Plymouth). No archaeological evidence has been found.

MANUTAHI BLOCKHOUSE

Early in 1865 a blockhouse was built at Manutahi, south of the redoubt which was the first military post in the vicinity (Prickett 1996:41). The shift from redoubt to blockhouse relates to the survey of a military township here ('Lepperton' after the commander of local forces in north Taranaki), and the taking up of land in the district by military settlers. By 1 April 1866 the garrison was down to one N.C.O. and three men (TMS Memo Book, 22 Mar 1866). Manutahi was occupied for the last time during the 1869 White Cliffs affair. On 24 February Corporal Turner was in charge of eight men (TMS Memo Book, 24 Feb 1869). The last man was struck off pay on 24 November 1869 (TMV Order Book, 23 Nov 1869).

The "Block House on Old Pa" is marked on a 1906 plan, "Township of Lepperton/ Paritutu Survey District", and on the relevant survey blocksheet (Paritutu VII: the field plan is in Fieldbook W.3, p. 50, LINZ, New Plymouth). It was situated behind the present Lepperton School. No archaeological evidence has been found.

MANGANUI BLOCKHOUSE

In early 1866 a blockhouse was built at the Manganui town site on low ground at the confluence of the Manganui and Waitara Rivers. In February Privates O'Connor and Bradley of No 7 Company, T.M.S., were asked if they would sell, "... one or two trees now growing on your Town Section to Government for the purpose of Building a Blkhouse at Manganui" (TMS Memo Book, 17 Feb 1866). Work on the building began in March (TMS Memo Book, 12 Mar 1866).

On 14 May 1866 Manganui Blockhouse was held by a corporal and three privates (TMS Memo Book, 10 May 1866). Construction was finished in June. The initial garrison left for Patea in September, but in this case occupation continued, as at other isolated frontier posts at Tikorangi, Mataitawa and Okato (AD1 66/4333). Manganui was abandoned in early 1867 (TMS Memo Book, 13 Feb 1867).

Although town and rural sections at Manganui were to be occupied by No 7 Company, T.M.S., the land was not taken up and Manganui Blockhouse later was shifted to Te Arei.

Major Brown, who was in command of the Taranaki military district, wrote in June 1869:

> The question of removing the Blockhouse originated with the Settlers who were in advance of Huirangi Blockhouse, and in rear of Manganui Blockhouse, and who offered to do the carting necessary to remove the latter. Under the circumstances that the Manganui Blockhouse was about two miles in advance of any settler to be protected, that it was ball proof in the sides, but untenable, being liable to a vertical fire, I recommended to His Honor the Superintendent that the buildings should be removed and re-errected [sic] at Te Arei. (AD1 70/834)

No archaeological evidence has been found at the Manganui Blockhouse site.

EGMONT VILLAGE BLOCKHOUSE

In the latter part of 1868 the Nga Ruahinerangi leader, Titokowaru, defeated colonial forces at Te Ngutu o te Manu and Moturoa in south Taranaki, to the alarm of European settlers over much of the west and south of the North Island (see Belich 1989). Settlers at Egmont Village doubtless felt more vulnerable than most, surrounded as they were by dense forest which extended south to the scene of Titokowaru's campaign. Probably the blockhouse was held by local settlers, many of whom are said to have served in the Taranaki campaigns.

The blockhouse was located near the corner of Junction and Egmont Roads, in what was to become the school grounds. From 1877 to 1879 it served as the settlement's first school. A corner of the single storey building may be seen behind the later school building in an 1880 photograph published in the school centennial booklet (Marsh 1977). The blockhouse is said to have been demolished early this century.

THE WHITE CLIFFS SCARE

A 13 February 1869 Maori raid on Pukearuhe resulted in a major scare on Pakeha Taranaki's northern frontier, and in renewed military activity throughout the region (Fig. 25). Much of this has already been outlined above in discussion of military posts dating from before 1869, several of which were re-occupied in response to the general alarm. In addition Waiiti and Papatiki Redoubts formed a new frontier 3 km south of Pukearuhe and other posts strengthened lines of communication north of Waitara.

TAKAPU REDOUBT

The first new post was at the corner of Otaraoa and the Inland North Road at Tikorangi. Sub Inspector Davis was ordered to Tikorangi school house on 27 February to, "... take immediate steps to throw up a redoubt around the building for the defence of the place" (TMV Order Book, 25 Feb 1869). But bad weather delayed matters (TMV Order Book, 27 Feb 1869), and it was 2 March before a force of A.C. under Captain Gudgeon and Captain Kelly's company of Bushrangers from Sentry Hill was at the site (AD1 69/2080). Next day a redoubt was marked out and work commenced.

On 5 April A.C. at Takapu were relieved by Captain McKellar's company of Bushrangers – enlisted at Thames and described as "Thames Volunteer Militia" (TMV Order Book, 4 Apr 1869). The A.C. appear to have returned, however, for orders were received on 20 April for the Bushrangers under Lieutenant Hursthouse and A.C. under Captain Tuke to move forward to Waiiti the next day (TMV Order Book, 20 Apr 1869).

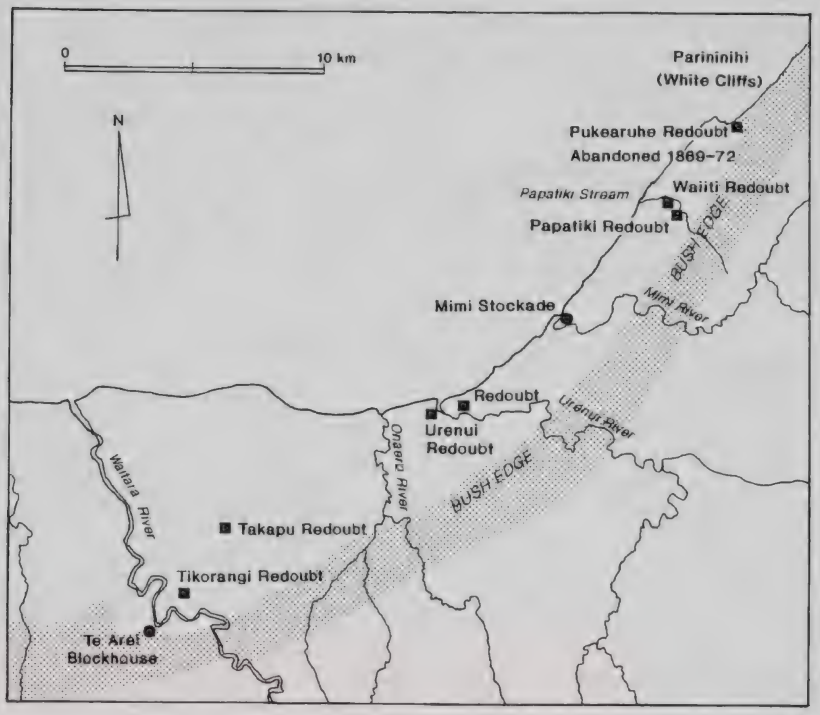

Fig. 25. Sites relating to the White Cliffs Scare, 1869.

In August 1869 the Takapu garrison comprised 18 Bushrangers under Sergeant Whitcombe (TMV Order Book, 11 Aug 1869). On 25 November it was reduced to one sergeant, one corporal and ten privates (TMV Order Book, 23 Nov 1869), and in March 1870 further reduced to five men on half pay (TMV Order Book, 11 Mar 1870). Takapu was abandoned on 1 November 1870 when three Bushrangers were ordered to rejoin their headquarters at Papatiki, and three remaining militia were struck off pay (TMV Order Book, 30 Oct 1870).

Takapu Redoubt was sited to secure the road north, and reassure Tikorangi settlers, most of them closer to the new position than to Tikorangi Redoubt on the hill at the boundary of occupied land. At this time the main road took the line of today's Inland North Road.

The redoubt is marked on the old series cadastral map (Waitara TN15), at the junction of Otaraoa and the Inland North Road, in the paddock at the south-east side of the corner. There is no surface indication of the size and shape of the earthworks, which are completely destroyed.

TE AREI BLOCKHOUSE

The Te Arei Blockhouse site was decided by Lieutenant Hursthouse of the Bushrangers in March 1869 (TMS Memo Book, 19 Mar 1869), and the Manganui Blockhouse shifted and re-erected in March and April (AD1 69/4231 in 70/834). Excepting New Plymouth, Te Arei was the last garrisoned post between Okato and the Waitara River, with one member of the local militia on pay at the post in 1870 (AJHR 1870 D-7:10). It was abandoned at the end of 1870 or in 1871.

The site is over Te Arei Road and the adjacent boxthorn hedge from Pukerangiora Historic Reserve, 50 m west of the 1864 Te Arei Redoubt (Fig. 26; see Prickett 1996:35-37). Surface evidence consists of a platform ca 12 x 7.5-10 m, with a shallow ditch to the south and ground

Fig. 26. Aerial photograph of the Te Arei Blockhouse site, 1975. The view is to the south. The site is under grass, right of the bend in Te Arei Road. Across the road, the ditches of the Te Arei Redoubt (1864) can be seen under pine trees, removed since the photograph was taken.

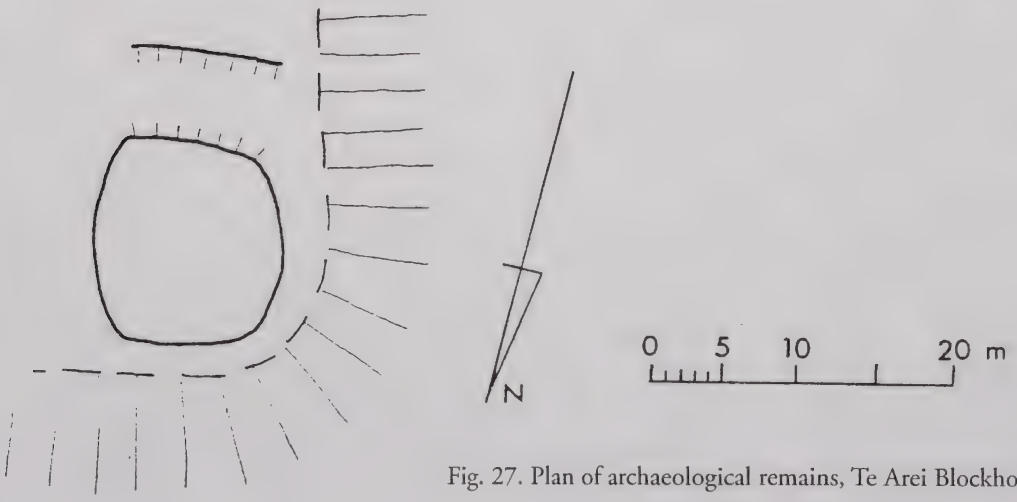

Fig. 27. Plan of archaeological remains, Te Arei Blockhouse.

falling away steeply to the north and west (Fig. 27). The remains were in good order in 1997. Among nearby farm buildings is an old shed with rifle slits in the weatherboards said to be from the blockhouse, demolished early this century.

WAIITI REDOUBT

Waiiti and Papatiki Redoubts were on the south bank of Papatiki Stream, 3 km to the rear of the abandoned fort at Pukearuhe. Both date from April 1869 when there were reports of 600 Ngatimaniapoto at Mokau, said to be about to advance and to occupy Tupari. Major Brown, who commanded local forces in Taranaki, wrote to the Under Secretary of Defence,

> I therefore on the 6th April moved with the Armed Constabulary and the Bushrangers (one hundred and fifty strong) to the Wai-iti about two miles this side of Clifton, a line of defence that better secures our line of communication, and to a greater extent interferes with Ngatimaniapoto's line of communication from Mokau with Tupari and Natimaru [sic], than the former camp at Clifton ... (AD1 69/2700)

Captain Tuke was ordered to Waiiti Redoubt on 20 April 1869, and remained in command at the post until 1872 (TMV Order Book, 20 Apr 1869).

Waiiti Redoubt was occupied throughout by Armed Constabulary, but for a few weeks in winter 1869 when Captain McKellar and 37 Bushrangers were stationed there (TMV Order Book, 5 Jul and 9 Aug 1869), and again briefly in 1870. At first the garrison was a strong one; Tuke was ordered on August 12 to reduce the A.C. No 7 Division at the post by discharge to 120 men—100 foot constables and 20 mounted (TMV Order Book, 9 Aug 1869). In 1870 the Waiiti garrison was reported as including 40 A.C., 41 local militia and two 'natives' (AJHR 1870 D-7:10). In 1871 47 Armed Constabulary were at the post (AJHR 1871 G-5:18), and in 1872, 37 A.C. (AJHR 1872 G-14:18).

On 11 September 1872 Armed Constabulary under Major Tuke moved from Waiiti to reoccupy Pukearuhe (P1/19 Taranaki). This greatly reduced the importance of Waiiti: the 1873 A.C. annual report puts the garrison at five men, and states that, "... the old redoubt at Wai-iti has been reduced in size, to accommodate a few men in charge of stores, horses, paddock, &c" (AJHR 1873 H-14:4). In 1874 there were three men at Waiiti (AJHR 1874 H-12:20), this being the last time the post is listed in reports.

The two redoubts on the Papatiki Stream made up the forward northern frontier of European Taranaki until Pukearuhe was re-occupied. The posts were responsible for supervising Maori movements across the frontier, as well as securing the area behind where soldier settlers were taking up confiscated land. Patrols were carried out to Pukearuhe and eastwards into the ranges and the Mimi River valley.

Sergeant Major Horsford, A.C., describes Waiiti Redoubt early in 1872:

> The redoubt at Wai/iti is on the upland, in an angle formed by a sharp bend of the Papatiki stream, it is commanded by high ground on all sides—at distances varying from two hundred to seven hundred yards. It is oblong in form, the dimensions, inside measurements, being 40 by 32 yards.
>
> The parapets are of the average height and thickness, and are built in the ordinary manner, with alternate layers of earth and fern. The ditch is about eight feet wide and about nine feet deep. The place is strengthened by three small bastions, one of which is circular in form, and built with a fern revetment from the base of the scarp. The two bastions which are of the ordinary form are very narrow at the neck, and their gorge

> scarcely admits of the entrance of one man at a time, they are furnished with port holes which command the ditch.
>
> The entrance to the Redoubt, which is on the south face, is covered by a traverse of earth, and a slab palisading is used to block up the gate at night. A gangway of earth affords a passage across the ditch, and this gangway is rendered safe for passengers by means of handrails on either side, these handrails however, are objectionable as fixtures, as they can be made use of as a sort of step on to the parapet.
>
> A serviceable drawbridge, to work with ropes and pulleys, would be a much simpler and safer mode of closing the redoubt than the present.
>
> The men are quartered in large and comfortable whares of raupo, and there is a good well inside the redoubt. (CD72/1151)

The Taranaki Museum holds an important group of four watercolours of the two redoubts by New Plymouth artist F.H. Arden. Figure 28 shows both works; another depicts only Waiiti Redoubt. The other two Arden paintings show Papatiki Redoubt (see Fig. 31).

Archaeological remains of Waiiti Redoubt are immediately above Pukearuhe Road 100 m north of the Waiiti Road corner (Fig. 29). In the 1970s the earthworks of the 1872 work were in good order, while outside, the larger 1869 work could be seen despite having been levelled for cultivation. At the southern angle of the early redoubt is the round bastion mentioned in Horsford's report. Huts and other buildings outside the redoubt could no longer be located from surface evidence. Pits which may relate to the A.C. period can be seen in the road cutting 50 m from the old redoubt. In 1997 pine trees had been planted on the site, threatening its long-term survival.

Fig. 28. Waiiti Redoubt, with Papatiki Redoubt at left rear. (F.H. Arden, Taranaki Museum.)

Fig. 29. Aerial view of Waiiti Redoubt, looking south, 1975. The remains of the destroyed part of the original work can be seen under short grass beyond the smaller, late redoubt. At right is Pukearuhe Road.

The surviving redoubt parapet was 800 mm high when visited in 1975, and unusually distinct for Taranaki works. The area enclosed is 25 x 11.5-14.5 m (Fig. 30). A causeway crosses the 5 m wide ditch at the south-west side to an entrance which is now 2.5 m wide. At the south-east side the ditch is 9 m in width, presumably following the reduction in redoubt size here from 32 m to 15 m. A drain crosses the interior of the work. At the northern corner an unusual buttress extends out 7 m, to add strength to this angle bounded at both sides by a steep scarp. The well, which would have been inside the 1869 work, appears to have ended up in the ditch on the north side of the causeway.

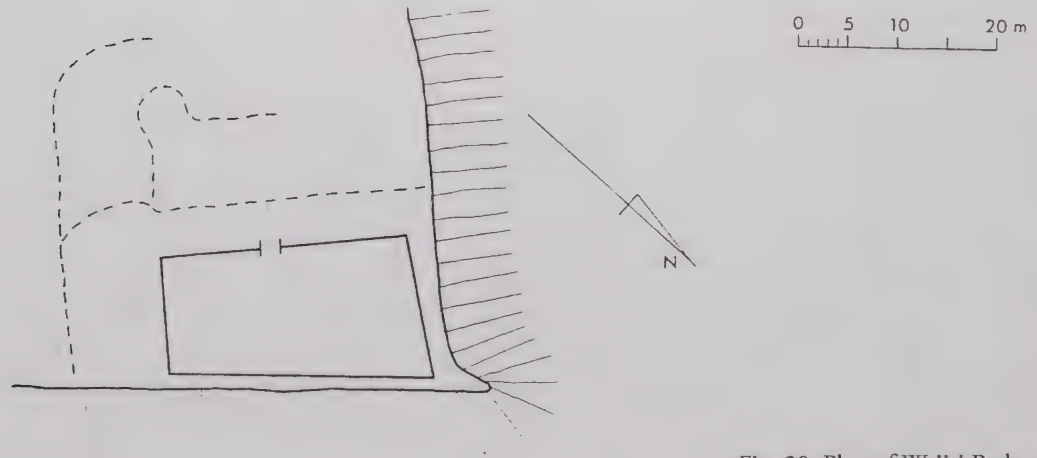

Fig. 30. Plan of Waiiti Redoubt.

PAPATIKI REDOUBT

Papatiki Redoubt was thrown up at the same time as Waiiti. It was occupied throughout by Taranaki Bushrangers, a volunteer force raised at the end of 1868 in the Thames goldfield, presumably in response to Titokowaru's successful campaign in south Taranaki. It is not clear who was initially in charge at the post: it may have been Captain Kelly, who commanded the Bushranger company. By June 1869 Captain W.B. Messenger was in command and remained so until Papatiki was abandoned.

The first reference to "Camp Papatiki" is given in District Orders for 8 September 1869 (TMV Order Book); until then there is some confusion in the records as the name 'Waiiti' is applied to both redoubts.

The size of the first Bushranger force at Papatiki is not known. A reduction to 50 men was ordered in August 1869:

> Captain Messenger will immediately on receipt of this order reduce the Bushrangers to 50 not including himself & Ens Johnson. Capt Kelly & all above 50 will be released from duty and struck off pay from the 12th Inst. Capt Messenger will be careful to select the most efficient men and those who know the country best & are the best bush men. 3 Serjts & 2 Corporals are to be retained and included in the fifty. (TMV Order Book, 9 Aug 1869)

By 31 March 1871 the Bushrangers at Papatiki were down to two officers and 29 men, the total force at the two posts now being 65 officers and men.

Papatiki Redoubt was abandoned at the end of 1871.

Fig. 31. Papatiki Redoubt. (F.H. Arden, Taranaki Museum.)

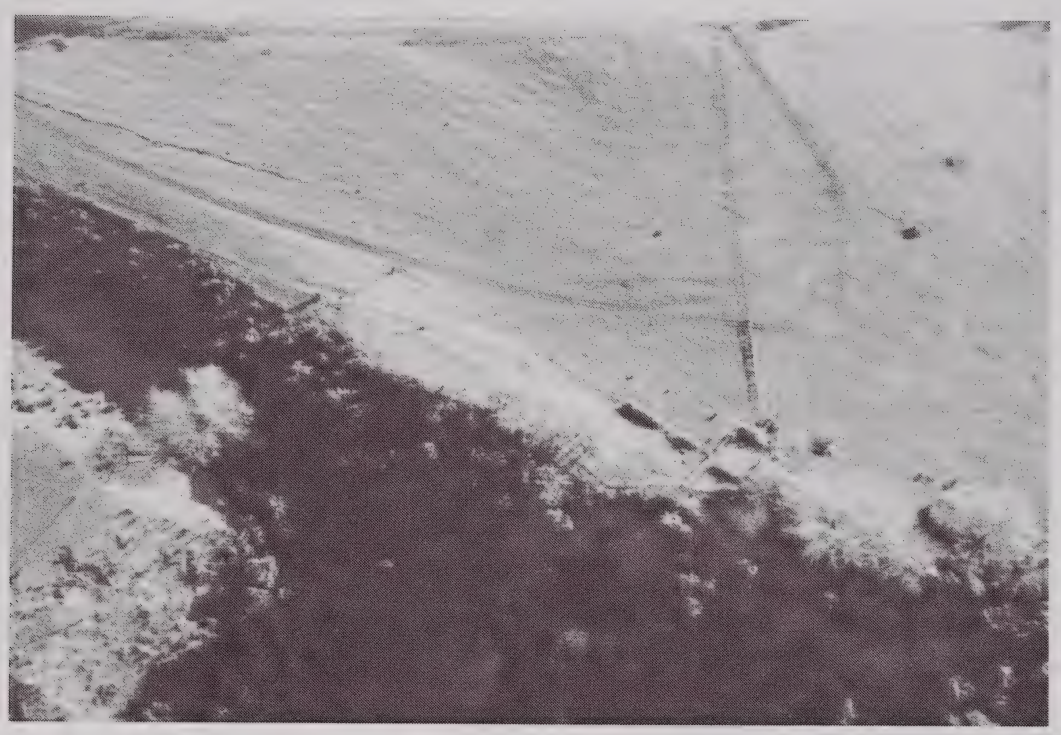

Fig. 32. Papatiki Redoubt. Aerial view to the north-west, 1975. The redoubt is in the centre of the picture, above the steep bank to the south.

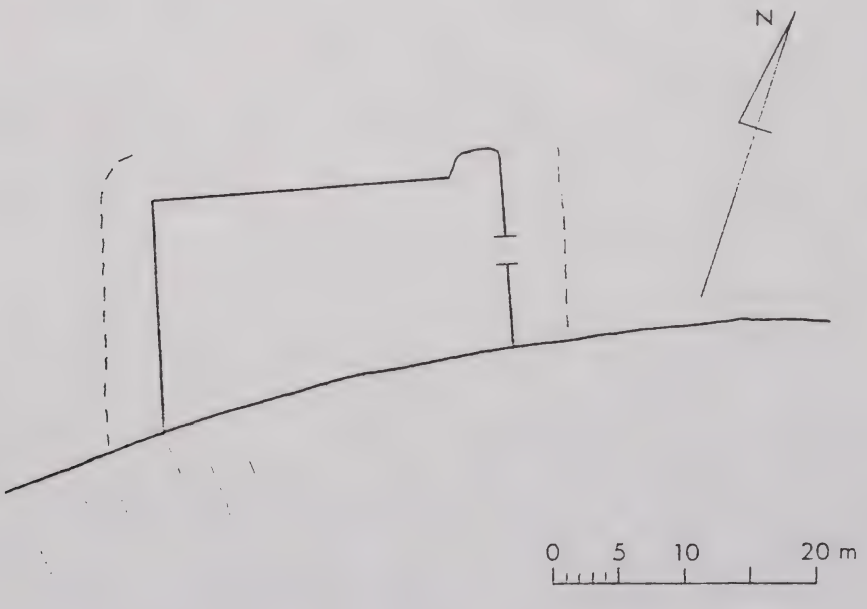

Fig. 33. Plan of Papatiki Redoubt.

> In accordance with instructions received from Government the whole of the Bushrangers are to be struck off pay, except Captain Messenger 1 serjeant and 7 Privates and the 2 Natives who are to be retained to do duty with the A.C. at Wai/iti.
>
> Previous to the men being struck off pay Captain Messenger will employ them to throw down the Redoubt at Papatiki. (TMV Order Book, 16 Dec 1871)

A contemporary picture shows a basically rectangular work, with flanking defence at the left rear to cover the north end and entrance-way and also near one end of the long side (Fig. 31). Inside are huts and tents; outside are also some huts. A second picture by the same artist depicts the south end, with flanking defence as at the north end. Semi-subterranean huts dug into the hillside show the Bushrangers to have had the same approach to providing accommodation as imperial and local troops in earlier campaigns. Cowan (1922-23:485) has published a sketch of Papatiki Redoubt by W.B. Messenger.

Papatiki Redoubt was ca 300 m south-east of Waiiti Redoubt, on a low ridge with a steep drop to the Papatiki Stream behind. The remains can be seen today 50 m east of Waiiti Road, 200 m from the Pukearuhe Road turn-off (Fig. 32).

The site was in good condition in 1997. The earthworks may have changed little since the work was thrown down in December 1871. The redoubt is 22.5 x 16 m in plan (Fig. 33). Flanking defence shown in the Arden sketches is still visible on the ground. A 4 m wide ditch surrounds the work except at the rear where the wall drops straight off down a steep bank to the stream. The sites of dug-out soldiers' huts can be seen south of the fortification.

A.C. REDOUBT NORTH OF URENUI RIVER

In the winter of 1869 a small redoubt was thrown up on the north bank of Urenui River to command the northern approaches to the Urenui ferry. Any name attached to the post is not known.

The history of the post is summed up by three district orders. On 2 June 1869:

> Capt Messenger will direct Capt Tuke Commdg A.C. to detail Fifty men including proportion of non Commissioned Officers under Sub Inspector Capel to proceed to Urenui on Monday next the 7th Inst & occupy a redoubt north of the Urenui River. Lieut Hursthouse T.M. Actg Engineer Officer will superintend the work ordered to be carried out & Sub Inspector Capel is to furnish working parties as requested by him. (TMV Order Book, 2 Jun 1869)

On 2 July 1869:

> Inspector Tuke is directed to instruct Sub Inspector Capel and 25 men to join Head Quarters at Wai-iti to morrow the 3rd Inst—weather permitting—a cart must be sent either to night or to morrow morning (to suit the tide) & convey the tents &c required. (TMV Order Book, 2 Jul 1869)

The post appears to have been abandoned in early August: "Sub Inspector Capel will march his Dett to morrow the 10th Inst. & join head quarters at Wai-iti" (TMV Order Book, 9 Aug 1869). The redoubt was thrown up by 50 men on 7 June, the garrison halved a month later and the post abandoned on 10 August.

The redoubt occupied a commanding site on the spur seaward of Urenui Beach Road, 100 m west of where the road dips down the hill (Fig. 34). The present road follows

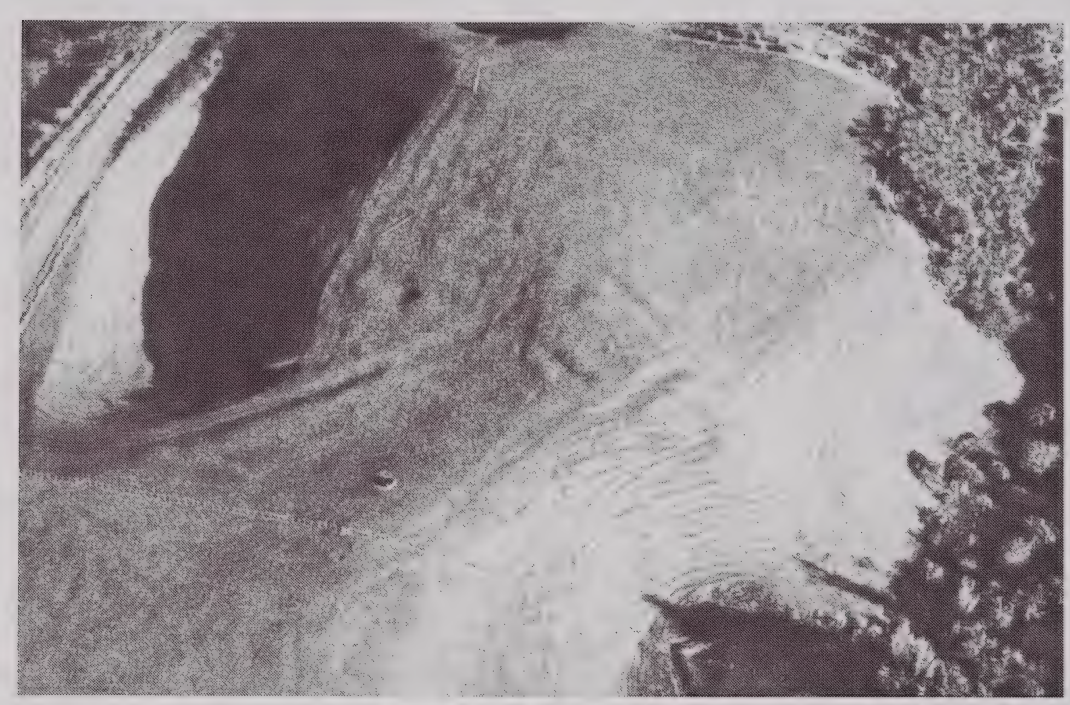

Fig. 34. Armed Constabulary redoubt at Urenui's northern approaches, 1975. Aerial view to the west.

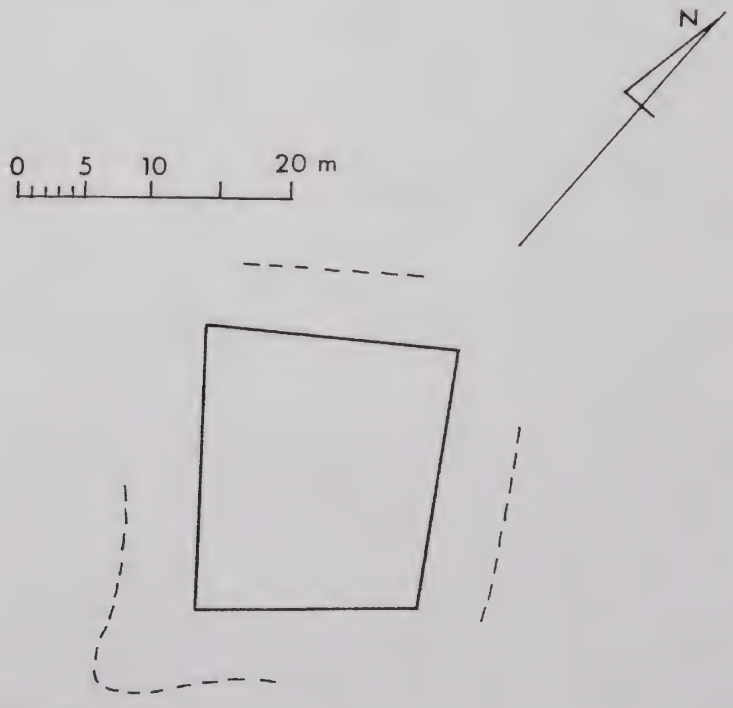

Fig. 35. Plan of A.C. redoubt, Urenui.

approximately the line of the old main road north of Urenui, which crossed the river by ferry at the site of the Te Rangi Hiroa memorial. In 1975 the site could be seen on the ground and from the air despite cultivation. It did not appear to have suffered further damage when seen in 1997. Surface evidence is of an off-square work ca 20 x 18 m without flanking defence (Fig. 35).

MIMI STOCKADE

In the 1860s the route north crossed the Mimi by ferry at the river mouth. In December 1866 a blockhouse was authorised north of Mimi but this appears never to have been built (AD6/6 66/2208/1). After the raid on Pukearuhe a stockade was built on the north bank of the Mimi to house ferrymen and protect the crossing, and to accommodate A.C. working parties in the area.

Just when the Mimi Stockade was built is not clear. On 24 February 1869 £100 was authorised for its construction (AD1 69/1112 in 70/3085). A 9 March minute, however, states that, "... the stockade at Mimi is not to be erected without further specific directions" (AD1 69/1310 in 70/3085). These directions have not been found.

An added difficulty in dating the work is that Maori at Mimi were put on half-pay after the White Cliffs raid as the only remaining force loyal to the government north of Urenui River (AD1 69/1792). (They are referred to as 'Chatham Islanders', being Ngati Mutunga who returned from there in 1868.) When a Maori garrison is reported at Mimi, this is likely to refer to these men living in existing settlements in the district. March 1872 reports, which describe the military landscape in north Taranaki, show no stockade at Mimi (P1/14 in CD72/1159).

The Maori volunteer force enlisted under Ihaia. District orders for 9 August 1869 include,

> Natives except Ihaia & 19 other to be struck off pay from 13th Inst. & will be distributed as follows 6 at Mimi, 2 at Kaipikeri, & 2 at Tupari, Ihaia & 9 at Wai-iti. (TMV Order Book, 9 Aug 1869)

On 20 December 1869 district orders stated that only two ferrymen are to be retained on pay, from among Maori volunteers of "Ihaia's force" (TMV Order Book).

About the end of 1874 work began on a bridge over the Mimi. This is likely to date the establishment of the Mimi Stockade.

> On the East Bank of the Mimi River, a party averaging 8 Eight ft constables have been stationed for over 18 mos... employed in bridging the river, a work of importance and no little difficulty, and in cutting the approaches thereto and continuing the road towards White Cliffs. (P1/30 Taranaki 1877)

This bridge was situated where Pukearuhe Road now crosses the river. In July 1877 it was reported that the Mimi working party had shifted to Waitoitoi (P1/34 271/77 Taranaki 1877), which may signal the abandonment of Mimi Stockade: the ferry was no longer in use and the line of road now followed the present route some distance inland.

Mimi Stockade is shown on the old series cadastral map (Mimi TN15). It was on a spur, which runs down to the north side of the Mimi River mouth (Fig. 36). The stockade was well sited to command the crossing at the river mouth, but surprisingly was overlooked by higher ground a few metres away on the same spur. In the 1970s, intact archaeological evidence was of a 6 x 8 m stockade platform surrounded by an infilled defensive ditch ca 4 m across (Fig. 37). A 1997 aerial reconnaissance showed that the remains were completely destroyed by recent earthworks for a house on the site.

Fig. 36. The remains of Mimi Stockade can be seen in the centre of this 1975 aerial view to the south-west, at the end of the spur above the river mouth.

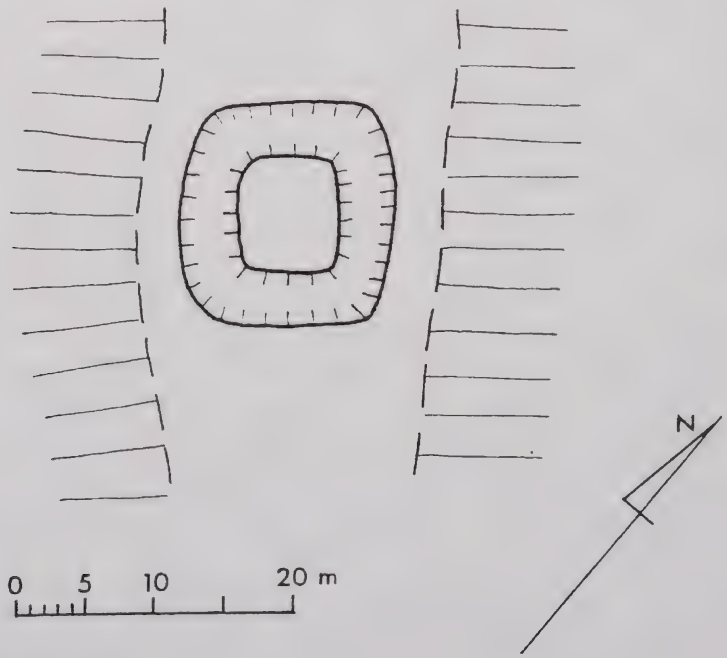

Fig. 37. Site plan of Mimi Stockade, 1975.

DISCUSSION

British Army and colonial fortifications in north Taranaki in the years 1865-69 are part of a larger picture of European fortified works and military strategy in the region dating from 1855 to the early 1880s. In the 1860s the struggle between Maori and European falls into three parts: the First Taranaki War of 1860-61, Second Taranaki War of 1863-66, and what I have called the 'White Cliffs Scare', 1869. Analysis of the role of fortifications requires a review of the 1860s as a whole, for which my two earlier articles (Prickett 1994a, 1996) also provide data.

At first, field works were concerned mostly with prosecution of the war by campaigning European forces - taking the war to the enemy and closing off the war theatre in north Taranaki to Maori reinforcements. From 1864 they were increasingly employed in the occupation of Maori land. This was the strategy by which the war was to be won, and at the same time Taranaki settlers' ambition for land would be realised.

THE FORTIFICATIONS

Thirty-one European fortifications date from the First Taranaki War, two being established by 1860. More than 50 fortified posts were employed at some time during the second war and the years to 1869, including those first put up in the war of 1860-61. Throughout the 1860s British Army and colonial forces in north Taranaki put up more than 70 fortified works in prosecuting the war against Maori and securing the frontier of European settlement. Table 2 summarises the works in terms of who was responsible, their initial purpose, and the form they took.

In the First Taranaki War and first year of the second war most forts were put up and held by British troops. Nine "shared works" in Table 2 are the blockhouses around New Plymouth occupied by troops and by local forces (Prickett 1994a:37). Local men were solely responsible only for the settler stockades at Omata and Bell Block. In the first war British strategy sought to defeat Maori forces in the field, and most fortifications were put up in campaigning situations. Many were tactical works, aimed at securing a battlefield advantage, in which they were unusual not just in Taranaki but in New Zealand as a whole.

At the start of the second war imperial troops again played the major role in taking the war to the enemy. Local forces were also responsible for campaign works at this time, often in conjunction with the forward movement of British troops. It was only in winter 1864 when blockhouses were erected in the districts behind New Plymouth that garrison or frontier works began to outnumber campaign fortifications, to reflect a changed European strategy. The struggle for Taranaki was now to be won by military occupation of Maori land. In the following year local forces put up blockhouses throughout the region to give security to military settlers.

The 1869 fortifications are the work of local forces only. Works of this group are difficult to place as campaign or frontier posts since they served both purposes, as indeed did other positions in the years before. Many redoubts were first put up in campaign situations, later taking on a frontier role. In general, frontier works in Table 2 refer only to those erected to secure or make safe the European farming frontier on previously acquired or confiscated land.

Table 2 shows the change from British Army to colonial works over the 1860s, and also a shift from campaigning works to fortifications designed to secure the European farming frontier. Most British Army works were employed in taking the war to the enemy, colonial works were used mostly in frontier defence.

In Table 2 can also be seen the relative numbers of earthwork redoubts and timber works. This relates to their use as campaign or frontier works. Redoubts were suited to the former: they could be thrown up quickly—under fire if necessary—and could accommodate

Table 2. European field works in north Taranaki, 1860-69, contrasting: 1. those put up by British troops and local forces; 2. campaigning works and those erected for a garrison or frontier role; and 3. earthwork redoubts and timber works (including stockades and blockhouses).

	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	TOTALS
1. Erected by:											
British troops	10	8		3	7	4					32
Local forces	2			1	10	9	1		1	6	30
Shared works	9										9
2. For the purpose of:											
Campaigning	8	8		4	11	4					35
Garrison and frontier roles	13				6	9	1		1	6	36
3. In the form of:											
Redoubt	6	7		3	8	7				4	35
Timber work	15	1			7	6	1		1	2	33
Combined work				1	2						3
TOTALS	21	8		4	17	13	1		1	6	71

comparatively large bodies of men. Most were the work of British troops, since it was they who were largely involved in the search for battlefield success in 1860-61 and the outward push of the campaigns of 1863-65. In later years more use was made of timber works, erected and manned by local forces. Blockhouses, stockades or combined blockhouse and stockade defence took days or weeks to erect, and were commonly used where a long-term role was envisaged for a small garrison. Timber works made secure the expanding European farming frontier.

Many British Army works of the Second Taranaki War were the responsibility of one Royal Engineer officer. Lieutenant Charles John O'Neill Ferguson was commissioned on 1 October 1857 (Hart 1862), so is likely to have been in his twenties when serving in Taranaki. He was responsible for St Patrick's Redoubt in 1863; Sentry Hill, Kaitake, Te Arei and Manutahi Redoubts (1864); and Stoney River and Opunake Redoubts (1865), and he almost certainly supervised construction of other works as well. Colonel Warre's criticism of the trace or construction of several fortifications provides interesting insight into the requirements of small fieldworks in New Zealand.

THE FRONTIER

The European military frontier in Taranaki went through several organisational phases in the 1860s (Fig. 38). In the war of 1860-61 (Phase 1) the defended frontier consisted of an entrenchment securing a tiny area of what is now central New Plymouth, plus a ring of blockhouses not much further out (Prickett 1994a:37). Beyond this, troops and local forces controlled no more than was within weapon range of the various fortified posts.

In the first year of the second war the situation was much the same. Outside New Plymouth

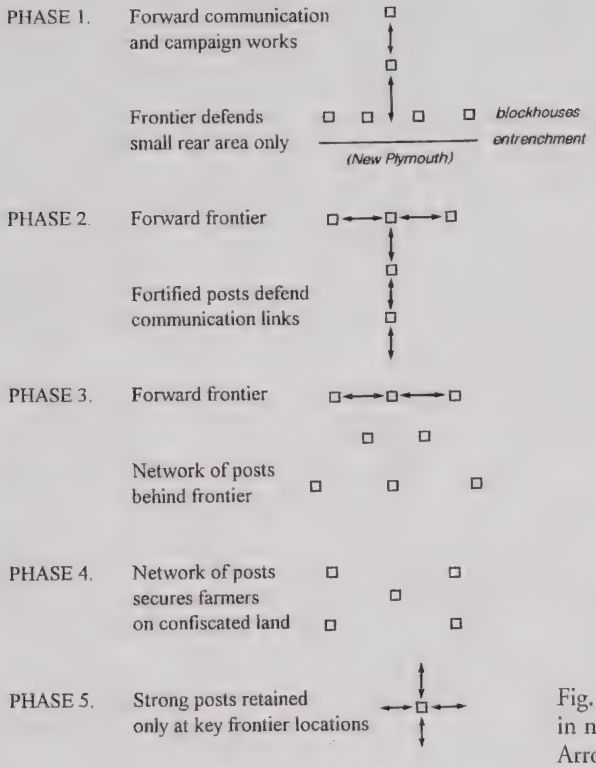

Fig. 38. Phases of military frontier development in north Taranaki, from 1860 to the early 1880s. Arrows indicate troop movements and patrols.

a handful of posts were isolated in a landscape largely controlled by Maori—at the end of 1863 these were the Bell Block Stockade north of New Plymouth, and Omata Stockade, St Patrick's Redoubt and Fort Robert to the south. When troops left Taranaki for the Waikato war in winter 1863 the local command lacked the resources for military initiatives. Only in February 1864 did troops return to Mahoetahi and throw up a new redoubt at nearby Sentry Hill, to begin the outward push of European control in north Taranaki.

There are two phases in the systematic development of Pakeha control of north Taranaki: the first (Fig. 38, Phase 2) closed off the region to Maori forces (Fig. 39); the second locked European control into place by the occupation of Maori land (Phase 3). Effective military control of the region began in March 1864 when Maori were driven from strongholds in the Kaitake Ranges and a southern frontier was fixed from the ranges to the sea at Oakura. In spring 1864 the north end of the inland track from south Taranaki was closed off in the Manutahi and Mataitawa districts; in autumn 1865 Pukearuhe was occupied to seal the northern approaches.

Two other military movements served to fix the boundary of European north Taranaki at this time. The January 1865 move to Hangatahua (Stoney River) secured a southern frontier, which remained in place until 1880. After the 1869 Maori raid on Pukearuhe a new northern frontier was fixed at Waiiti, before returning to Pukearuhe in 1872. The Stoney River and White Cliffs military frontiers were abandoned only with the end of effective Maori independence in coastal Taranaki and the King Country respectively. After the 1880-81 Parihaka

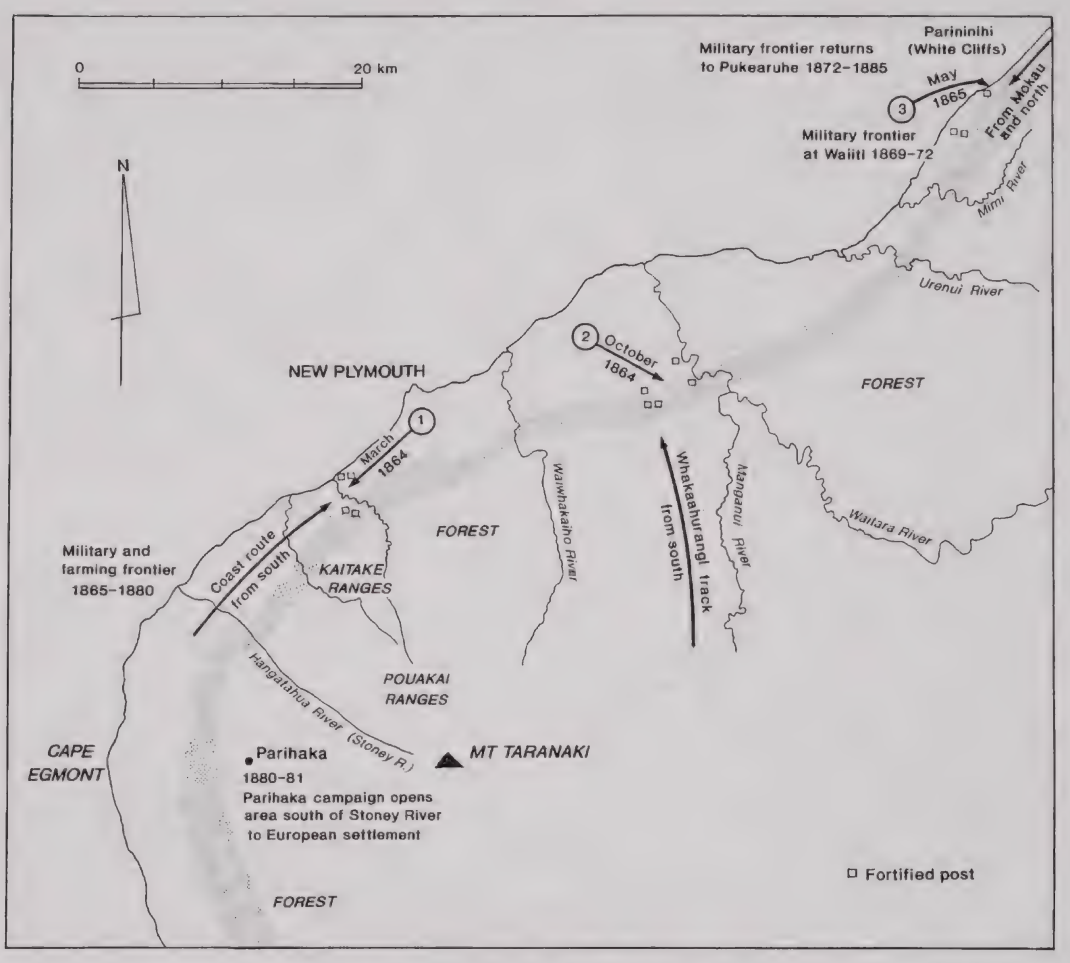

Fig. 39. Major European military movements and their related fortifications in Taranaki, 1864-1881.

campaign a strong forward post was maintained at Opunake to the mid-1880s, matching the post at Pukearuhe which was strongly held until agreement with the King Movement opened the King Country to European settlement.

Once the military frontier was secure, the farming frontier quickly followed (Fig. 40). When Maori forces were evicted from the Kaitake Ranges in March 1864, blockhouses behind New Plymouth were all that was needed to reassure returning farmers who had left their land at the outbreak of war in 1860. The same applied for returning farmers at Tataraimaka in early 1865. Beyond the pre-war farming districts, expansion of the European farming frontier was in the hands of military settlers.

An inch-to-the-mile cadastral "Map of Taranaki County", published in 1934 by the Surveyor-General, shows the pattern of confiscated land in north Taranaki. Townships at Tikorangi, Manganui, Huirangi, Mataitawa, Lepperton, Koru (Tuahukino), Ahu Ahu and Okato are surrounded by their town belts and the surveyed rural land awarded to military settlers. Another township was laid out at Pukearuhe (Clifton)—for which Taranaki Museum has a manuscript

plan dated September 1865, with the names of men on their selected sections.

Rural land was awarded according to rank. In the case of land allocated to the Tikorangi Volunteers, captains received 300 acres, lieutenants 200, ensigns 100, sergeants 80, corporals 60, and privates 50 acres. Each man also received a quarter acre town allotment ("Conditions upon which land will be given to settlers on the north of the Waitara", AD 31/1). Land was selected according to rank: officers chose their large blocks first, pushing 50-acre selections to poorer land at the settlement margins.

For a time there were forward frontier works held by British troops as well as a network of military settlement blockhouses to the rear. In the south there were strongly held imperial works at Stoney River, Warea and Opunake from early 1865 to May 1867 when the 50th Regiment was withdrawn prior to its departure for England. During this time the European farming frontier was established to Stoney River. In the Lepperton district there was a large garrison at Te Arei to early 1866, Mataitawa Redoubt also being strongly held by troops and Taranaki Military Settlers until Chute's march inland of Mt Taranaki in January 1866.

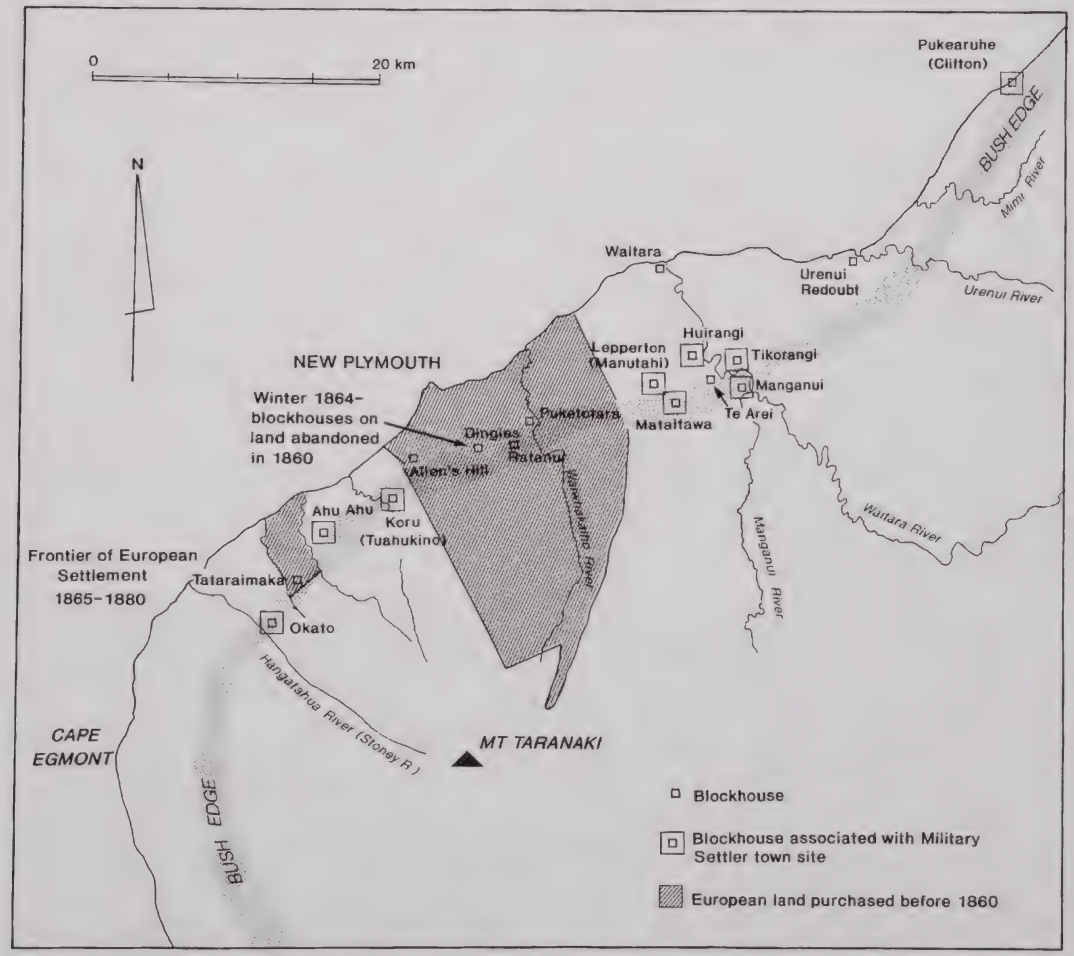

Fig. 40. Holding the land: blockhouses and military settler town sites in north Taranaki, 1864-69.

At the northern frontier the strong forward defence which was characteristic of this phase of frontier development ended in 1866 with reduction of the garrison at Pukearuhe. May 1867 saw the departure of British troops from Stoney River, Warea and Opunake. For a few years the strong forward posts were abandoned, to leave only the network of blockhouses which secured the farming frontier (Phase 4). Proof that the reduction in forward strength was premature came with the February 1869 Maori raid on Pukearuhe, when those remaining were killed and the post burned.

Thereafter a strong military presence was maintained in the north, at Waiiti from 1869 to 1872 and subsequently at Pukearuhe, behind which European settlers set about transforming the land (Phase 5). In the 1870s, at the southern frontier there was a small garrison only at Okato. As a result of the operations against Parihaka, however, a large Armed Constabulary presence was maintained in the early 1880s at the forward post of Opunake, matching the A.C. strength at Pukearuhe.

By the 1870s most blockhouses served only as parade posts and assembly points for discharged military settlers in the districts. Only with the destruction of Parihaka and the opening up of the King Country was there confidence enough to dismantle the physical remains of the military frontier in north Taranaki. It can be argued that the volunteer movement thereafter maintained the unequal power relationship with the former enemy, and thus the confidence of the Pakeha community; but this is not part of the story told here.

Acknowledgements. This work has benefited from the input of many people. I especially thank Kath Prickett, Ron Lambert, Alastair Buist, and staffs of the former Lands and Survey Department (New Plymouth), Taranaki Museum, New Plymouth Public Library, Alexander Turnbull Library (Wellington), and Australian National Library (Canberra). Particular thanks are due to Neville Henry of New Plymouth who drew my attention to the blockhouse at Egmont Village, and Mr D.R. Rinckes who kindly gave permission for the publication of Fig. 13. I would like to dedicate this paper to the late Dr Alastair Buist, who died as it was going to press.

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APPENDIX 1. New Zealand Archaeological Association site record numbers and map references for fortifications referred to in the text. Approximate map references are given where the location is known but archaeological evidence has not been found.

Armed Constabulary redoubt north of Urenui River Q19/224 312450
Ahu Ahu Blockhouse P19 ca 908285
Egmont Village Blockhouse P19 ca 090282
Manganui Blockhouse Q19 ca 210360
Manutahi Blockhouse Q19 ca 147373
Mimi Stockade Q19/60 349482
No 2 Company redoubt, Onaero Q19/165 259412
Okato Blockhouse P19/47 865228
Opunake Redoubt P20/18 839937
Orongomaihangi P19 ca 840270
Papatiki Redoubt Q18/40 394523
Pukearuhe Redoubt Q18/80 415556
Puke Ti P19 ca 870250
Stoney River Redoubt P19/33 ca 832253
Takapu Redoubt Q19/164 221407
Tataraimaka Blockhouse P19/46 ca 884255
Te Arei Blockhouse Q19/154 192369
Tikorangi Redoubt Q19/153 209381
Tuahukino Blockhouse P19 ca 960300
Tukitukipapa P19/119 853288
Urenui Redoubt Q19/27 302449
Waiiti Redoubt Q18/41 391529
Warea Redoubt P20/17 770187

HISTORY OF THE LAND VERTEBRATES COLLECTION AT AUCKLAND MUSEUM, NEW ZEALAND, 1852-1996

B. J. GILL

Abstract. Land vertebrates, especially birds, have been an important part of the Auckland Museum collection since the museum's foundation in 1852. Auckland Museum grew rapidly in the last quarter of the 19th Century, at a time when natural history and ethnology museums were flourishing throughout the Western world. This period of growth was expertly guided by T.F. Cheeseman, a botanist, who ran Auckland Museum for nearly 50 years from 1874. The collection of land vertebrates was enhanced by major exchanges of specimens that Cheeseman negotiated with foreign museums, and dealers like H.A. Ward, during the period 1875-1905. The museum's first attempt to show land vertebrates in the context of their habitats were small displays of tuataras and keas in 1886. "Habitat groups" were a constant feature of Auckland Museum's natural history displays from 1912. The bird gallery in the 1929 building, continuously improved, served for 40 years. Its replacement in the 1960 extension, containing some large and superb dioramas, remained open for 24 years. This article traces the development of land vertebrates exhibits and reference collections at Auckland Museum to 1996. Staff who had charge of the collections (besides Cheeseman) included L.T. Griffin, G.E. Archey, R.A. Falla and E.G. Turbott. Taxidermists who prepared specimens for the collection included I. St John, A. Reischek, C.F. Adams, L.T. Griffin, C.W. Dover and P.J. O'Brien. Particular attention is given to some of the larger display items, to the oldest specimens in the collection and to the sources of major acquisitions of specimens.

KEYWORDS: Birds; moas; mammals; "Rajah" the elephant; museum collections; registration; exchanges of specimens; museum exhibits; dioramas; curators; taxidermists.

INTRODUCTION

New Zealand's four main natural history museums, geographically spread in what are today's four major centres (Auckland, Wellington, Christchurch and Dunedin), all began in the Victorian era. Auckland Museum is one of the oldest, founded in 1852, just 12 years after New Zealand became a British Colony. For much of its history Auckland Museum has also been known as the "Auckland Institute and Museum" (1867-1996) and "Auckland War Memorial Museum" (1929-present).

At their humble beginnings in the young colony, the New Zealand museums had little money and sole-charge, often honorary, curators. There were problems in expertly preparing natural history specimens and storing and displaying them properly. Much material was sent directly to northern hemisphere experts and institutions, particularly in Britain, for determination or description. Thus, New Zealand museums tend to have little local natural history material from before 1880, and any specimens surviving from this era tend to be poorly documented.

In the late Victorian years, New Zealand museums reached a sounder footing, at a time when natural history museums around the world were flourishing (Sheets-Pyenson 1988). The curators, still mostly sole-charge, were notable scientists of the time, and the natural history collections were enriched by international exchanges of specimens. The New Zealand museums became major scientific institutions (Cheeseman 1917). Their scientific output has continued, but by the 1940s they were overshadowed in this role by the growth of the universities, and the rise of government research departments.

Since the 1920s, when budgets or attitudes began to allow appointment of multiple specialist curators, New Zealand's main museums have sought to emulate the great museums of Europe and North America by providing modern displays and developing and maintaining large reference and research collections.

By considering the history of the land vertebrates collection (birds, reptiles, amphibians and non-cetacean mammals) at Auckland Museum, I have sought to trace the growth and development of a New Zealand natural history collection. One of the objectives of Auckland Museum at its founding was "to collect specimens illustrative of the natural history of New Zealand" (Powell 1967: 8). Land vertebrates were important from the start, for the founding collection comprised "... some handsome stuffed birds, shells, insects, and various other things amongst which an hour may be very agreeably and instructively spent" (*The New Zealander* 27 October 1852).

Started with a few stuffed birds provided by local colonists, the Auckland Museum land vertebrates collection now comprises 800 land mammal specimens, 2,000 amphibians and reptiles, 11,200 birds and 29 primary type specimens (Gill 1983 and unpublished). The end-point for this review is 1996, in March of which the 1972 Hall of New Zealand Birds closed to the public and was dismantled.

Throughout this paper "Ann. Rep." refers to the *Annual Report of the Auckland Institute and Museum*, first published in 1871 for the financial year 1870-71. Previous papers dealing with Auckland Museum's history are Cheeseman (1917), Powell (1967), Mason (1996) and Park (1999).

MUSEUM BUILDINGS

When Auckland Museum was founded in October 1852 it occupied two rooms in a farm cottage on the hill above the town, near what is now the junction of Grafton Road and Symonds Street (Powell 1967). In 1867 the museum moved to a large room in the present Northern Club building in Princes Street. From 1869 to 1876, Auckland Museum occupied the "old Post Office", a humble wooden structure also in Princes Steet. On this site a new museum building was erected (Fig. 1). It was officially opened on 5 June 1876 by the Governor, the Marquis of Normanby (Cheeseman 1917), and was subsequently extended several times.

The museum moved to a new building on a hill in the Auckland Domain opened on 28 November 1929 by the Governor-General, General Sir Charles Fergusson. The building is a memorial to those from the former Auckland Province who died in the Great War (1914-18). It contains three floors (ground, first and second), devoted then, as now, largely to display galleries. The 1929 building was later doubled in size by extension to the rear. Work began on the extension in 1956 and it was opened on 19 March 1960 by the Governor-General, the Viscount Cobham (Powell 1967). The extension was built in memory of those from the Auckland provincial area who lost their lives in World War II (1939-45). The extension contains additional gallery spaces on three floors extending those in the front part of the building. The curved rear portion of the extension contains administrative and storage areas on four floors (ground, mezzanine, first and second). The extended building is the museum's present home.

Fig. 1. The 1876 museum building, Princes Street, 15 August 1917. The inscription on the facade reads "Institute and Museum". The large building to the right is the 1892 extension. Cheeseman's office was behind the two windows at ground level left of the entrance. The building has not survived. Photo: H. Winkelmann (Auckland Museum Library, C23824).

STAFF

The museum's collections during its earliest years were under the care of a succession of local citizens, most notably John Alexander Smith (1814?-1889), the museum's founder (Park 1999). These honorary curators were nearly all amateurs, and with the study of natural history in the colony at its infancy, making sense of many exhibits was difficult. Even putting a name to birds was a problem, as shown by an 1856 letter from Smith to St John, a taxidermist in Nelson, in which Smith mentioned a "Black & White Bird with Red Bill" (Park 1999), presumably an oystercatcher (*Haematopus*).

One honorary curator who went on to become prominent in New Zealand zoology was Frederick Wollaston Hutton (1836-1905), who appears to have had charge of the collection in 1867, arranging it in the new premises after the move to the Northern Club building (Park 1999). For a full account of those overseeing the museum from 1852 to 1867, see Park (1999). From 1868 to 1874 it seems the museum was run by Thomas Kirk (1828-1898), a botanist (Powell 1967). Staff who have had a managerial or technical connection with the land vertebrates collection at Auckland Museum, beginning with Kirk, are listed in Table 1.

Thomas Frederic(k) Cheeseman (1845-1923; Fig. 2) was appointed sole curator of the museum in 1874 and headed the museum for half a century until his death (Cockayne 1923, Goulding 1996, Powell 1967). Born in Yorkshire, he came to New Zealand with his parents at eight years old. Cheeseman was primarily a botanist, but published also on zoology and ethnology. Among many honours he was elected a Fellow of the New Zealand Institute, and of the Linnean and Zoological Societies of London.

Table 1. Staff who have managed the land vertebrates collection at Auckland Museum, 1868-1996. The asterisk (*) indicates responsibility wider than the land vertebrates collection. See Park (1999) for details of honorary curators during the period 1852-1867.

Person	Title and period employed
T. Kirk	Secretary, Auckland Institute* 1868-74
T.F. Cheeseman	Curator* 1874-1923
L.T. Griffin	Assistant/Preparator* 1908-22, Assistant Curator* 1923-35
G.E. Archey	Curator* 1924-29, Director* 1929-64
R.A. Falla	Honorary Ornithologist 1928-30, Ornithologist 1931-35, Assistant Director* 1935-37
E.G. Turbott	Assistant Zoologist* 1937-43, Ornithologist-Entomologist* 1945-57, Director* 1964-79
G.A. Buddle	Acting Ornithologist 1943-45, Associate Ornithologist (part-time) 1945-51
L.J. Wagener (née Bishop)	Recorder (Zoology)* 1960-68
H.R. McKenzie	Associate Ornithologist (part-time) 1968-72
S.M. Reed	Associate Ornithologist (part-time) 1972-81
B.J. Gill	Curator of Land Vertebrates 1982-present
J.L. Riley (née Oats)	Zoology Technician* 1987-96

In 1908, Louis Thomas Griffin (1871-1935; Fig. 3) was appointed assistant to Cheeseman and Preparator. He had trained at Regent's Park Zoo, London, and had worked in South Africa at Pretoria's National Zoological Garden (Wood 1992), and as Preparator at museums in Capetown and Pretoria. Among many duties at the museum, Griffin catalogued much of the land vertebrates collection, and conducted research on fish taxonomy.

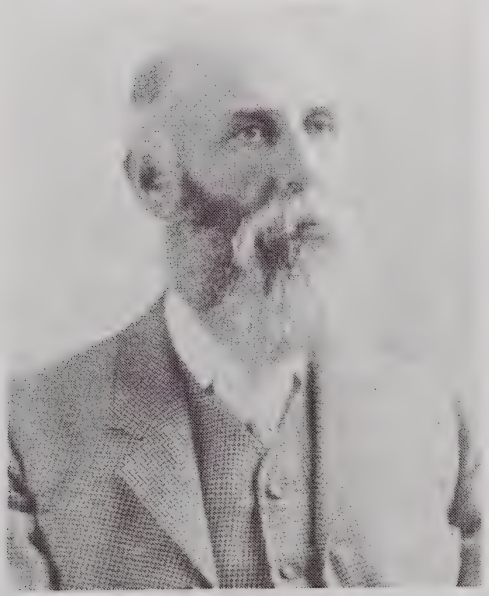


Fig. 2. T.F. Cheeseman, c. 1900 (Auckland Museum Library, C27027).

Fig. 3. L.T. Griffin in a basement workroom at Auckland Museum, 1909. Photo: *New Zealand Graphic* (Auckland Museum Library, C8689).

Cheeseman was succeeded as Curator by Gilbert Edward Archey (1890-1974), who was also Yorkshire-born, and who came to New Zealand with his parents at the age of two. The title of Curator was changed to Director in 1929 with the move to the new building. Archey had broad interests and pursued zoology early in his career, later diverting much attention to the study of Maori art (Turbott 1975). He amassed most of the museum's large moa bone collection and published a major study of moas (Archey 1941). His career as Director was interrupted by war service, with the home forces from 1939 (as Lieutenant-Colonel) and then with the British Military Administration in Malaya until 1947. He was knighted in 1963.

By the late 1920s the museum had grown to the extent that specialised curators were required. Robert Alexander Falla (1901-79; born in Palmerston North) was appointed Honorary Ornithologist in 1928. He was granted leave from, and later left, Teacher Training College in Auckland to work as Assistant Zoologist on Sir Douglas Mawson's British, Australian, New Zealand Antarctic Research (B.A.N.Z.A.R.) Expeditions during the summers of 1929-30 and 1930-31 (Fleming 1980). He took up a permanent position as Ornithologist at the museum in 1931 and managed the bird collection until 1937 when he left to become Director at Canterbury Museum.

In 1937, Evan Graham Turbott (1914- ; born in Auckland) was appointed Assistant Zoologist. He had completed an M.Sc. study on the biology of one of New Zealand's native frogs, but the main interest during his career was to be birds. Turbott was absent 1943-45 on war service that included a year at the coast-watching station on the subantarctic Auckland Islands as part of the "Cape Expedition". During this time Geoffrey Armstrong Buddle (1887-

1951) was Acting Ornithologist. Buddle was a Gallipoli veteran and pioneering nature photographer (Sibson 1975). He continued as part-time Associate Ornithologist from 1945 until his death, and in this time he catalogued much of the egg collection. Turbott continued to have oversight of land vertebrates until he left in 1957 for a position at Canterbury Museum.

Lois J. Wagener née Bishop served as Recorder (Zoology), 1960-68. Among various duties she prepared skeletal specimens and recatalogued and reorganised Archey's moa bone collection. Turbott returned to Auckland Museum as Director in 1964. The daily running of the land vertebrates collection was undertaken from 1968 to 1981 by part-time amateur Associate Ornithologists. Hector Ross McKenzie (1897-1981) of Clevedon (Brown 1990) served in this capacity from 1968 until 1972. Sylvia Mary Reed (1915-81) succeeded him in 1972 until her death (Sibson 1982). She greatly expanded the collection of bird and mammal bones. During the 1970s, Arthur Brett Stephenson (1945-), the museum's Marine Biologist, had partial oversight of the herpetology and mammalogy collections.

The collection was again managed full-time by a zoologist when Brian James Gill (1953-) was appointed Curator of Land Vertebrates in 1982. From 1987 to 1996 he was assisted part-time by Jenny Louise Riley née Oats (1964-).

TAXIDERMY

Table 2 lists all those known to have been engaged to prepare specimens of land vertebrates for Auckland Museum to 1996. In the period before 1880 only one name has come to light. Correspondence of the museum's founder, J.A. Smith, shows that in 1856-57 the museum engaged the collector and taxidermist Mr I. St John of Nelson to supply mounted native birds that he had caught and prepared locally (Park 1999). That St John worked from afar was presumably tolerated because there were so few with taxidermy skills in the young colony.

Many of the birds and mammals received by the museum in the 1800s, including those exchanged internationally, seem to have arrived in an unfinished condition and required the attentions of a taxidermist before they could be displayed. In 1878-79, some 300 birds and 30

Table 2. Taxidermists, preparators and technicians who have been engaged to prepare specimens of land vertebrates for Auckland Museum, 1856-1996.

Person	Period engaged
I. St John	1856-57
A. Reischek	1880-81
C.F. Adams	c.1885-87, c.1889
L.T. Griffin	1908-35
C.W. Dover	1929-1953
P.J. O'Brien	1953-58
L.J. Wagener	1960-68
L.J. Cappel	1964-82
T.A. Jenkins	c.1966-1984
M. McCluskie	c.1972-1982
B. Wadham	c.1984-1987
J.L. Riley	1987-96

mammals were able to be mounted and placed on exhibition (Ann. Rep. 1878-79: 10) implying some access to a taxidermist. However, the following year it was noted that all mammals and birds received in the past two years were "still packed away in cases, the funds of the Institute not being sufficient to defray the salary of a taxidermist" (Ann. Rep. 1879-80: 9).

The museum's first notable taxidermist was the Austrian Andreas Reischek (1845-1902). "A temporary arrangement has been made with the well-known taxidermist, Mr A. Reischek, and a large proportion of the skins that have been accumulating for the last few years has already been set up" (Ann. Rep. 1880-81: 9). His engagement was made possible by a donation of £25 from a private benefactor, and by the raising of over £60 by a "Conversazione" held at the museum on two evenings in September 1880 (Ann. Rep. 1880-81: 9, Powell 1967: 16). The 1881-82 annual report indicates that Reischek was retained for only a portion of that year, "remounting and adding fresh specimens to the collection of New Zealand birds". There was another fund-raising conversazione in June 1881 (King 1981: 66).

Reischek was an energetic hunter and an accomplished taxidermist (King 1981, Prebble 1993, Westerskov 1990). He spent 12 years in New Zealand (1877-1889). The Reischek specimens surviving in the Auckland Museum collection were collected or received between 1878 and 1888. However, it seems he was employed as Taxidermist at Auckland Museum only during the period 1880-81, after which New Zealand bird skins and skeletons were purchased from him (e.g. Ann. Rep. 1885-86).

Auckland Museum gave Reischek a citation dated February 1889, signed by Cheeseman and the president and vice-president of the museum's governing body (Aubrecht 1995). It records appreciation of the "valuable services rendered to the cause of science in New Zealand by Mr A. Reischek", referring to "12 years of unwearying and enthusiatic devotion in studying the Natural History ... of the Colony" and to his "valuable and generous aid in enriching the Natural History Collections in the Museums of the Colony".

The 1882-83 annual report indicates that a taxidermist could not be paid for that year, but a "competent osteologist" was engaged temporarily to prepare some articulated skeletons. In the 1883-84 year a permanent taxidermist looked imminent ("a thoroughly competent workman has been selected, and in a few months will arrive in Auckland"), however, he died and another had to be selected (Ann. Rep. 1884-85). H.A. Ward of Rochester, U.S.A., made the selection, and the taxidermist arrived in Auckland (Ann. Rep. 1884-85: 7), presumably from America. In the next annual report no taxidermist is mentioned, but it seems that Ward selected C.F. Adams (of Illinois, U.S.A.), described in the 1888-89 annual report (p. 7) as having been "formerly employed as taxidermist to the Museum". In 1886-87 further birds were mounted for exhibition (Ann. Rep. 1886-87), presumably by Adams. No taxidermist was employed the following year (Ann. Rep. 1887-88). Adams had evidently returned to the United States, but in 1889-90 a collection of Bornean mammal skins purchased from him were "placed in his hands for mounting" (Ann. Rep. 1889-90).

The annual report of 1895-96 lamented that the museum's inability to employ a taxidermist meant that an opportunity was lost to obtain a large adult leathery turtle *Dermochelys coriacea* that had been captured in the Bay of Islands. This state of affairs continued—for example: "The Zoological department is practically at a standstill from the inability of the Institute to employ a taxidermist" (Ann. Rep. 1900-01). The last such complaint was in the 1907-08 annual report where it was stated that New Zealand's other main museums each had a taxidermist on the permanent staff. Finally in 1908 it was resolved to employ "a resident taxidermist, or preparator of specimens" (Ann. Rep. 1908-09).

Following enquiries in Britain and the U.S.A., L.T. Griffin was recruited from South Africa. The following year all the exhibited birds and mammals were "cleaned and renovated, and

remounted in a more modern style" (Ann. Rep. 1909-10). Many inferior and faded New Zealand birds were replaced by better and "more artistically-mounted examples". Griffin experimented with "gelatine casts" of tuataras (*Sphenodon*) and other reptiles which were painted for display (Ann. Rep. 1910-11). Among his activities in the 1911-12 year he mounted 81 reptiles, birds and mammals, as well as preparing study-skins, alcoholic specimens, skeletons and casts. He built a reconstruction of the giant moa *Dinornis giganteus* (Figs 14, 17) in 1912 and 1913 using emu feathers, and mounted several large specimens, including an ostrich, for a new case containing ratite birds (visible in background of Fig. 7).

Charles W. Dover (Fig. 4) was an accomplished taxidermist of the British school (E.G. Turbott, pers. comm.) and served at the museum for 24 years. He prepared excellent mounts and study-skins, redid field skins prepared by Falla and Turbott, prepared mounts and skins from spirit specimens, and relaxed mounts. He mounted the Indian elephant "Rajah" (Fig. 4) that was displayed for many decades. In 1934 "a fine series of water-colour drawings of native birds, by Mr Dover" was exhibited as part of a special exhibition on the natural history of the

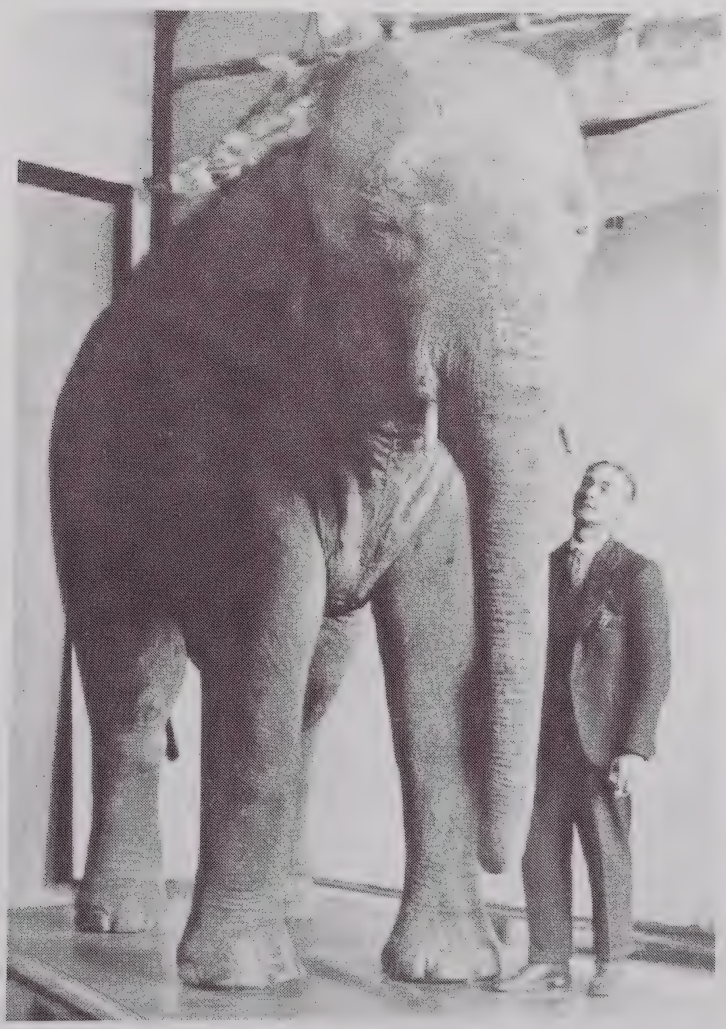


Fig. 4. The taxidermist Charles Dover, beside the elephant "Rajah" that he had recently prepared for display, 1936. (Auckland Museum Library, C30455.)

Hauraki Gulf (Ann. Rep. 1934-35). Dover articulated moa skeletons collected by Archey and colleagues. Among tasks he was diverted to during war years was the production of sets of models of tropical fruits for Royal New Zealand Air Force "instructional depots" (Ann. Rep. 1944-45).

Dover was succeeded by Patrick J. O'Brien who had previously been a preparator at Canterbury Museum, and who left to take a position at Otago Museum. O'Brien built a series of small but exquisite dioramas showing life through the ages. In 1964 Leo J. Cappel (1933-) was appointed Preparator. He prepared some mounted birds and study-skins but was engaged mainly in installing dioramas and general displays. In the early 1980s, after Cappel departed, the Preparator's department became a Conservator's department, focussing almost entirely on ethnographic conservation, and the museum was once again without taxidermy skills.

From the mid-1960s until 1987, the museum engaged outside commercial taxidermists (most notably Terry Jenkins at Clevedon; see Table 2 for others) to produce mounts and study-skins. Many of the mounts were good, but these taxidermists lacked museum training and few of the study-skins were well prepared.

During the period 1987-96 the part-time land vertebrates technician (J. Riley) produced well prepared and properly documented study-skins. The few mounts obtained during this time were done commercially.

REGISTRATION AND CATALOGUING

The state of documentation of Auckland Museum's early land vertebrates specimens owes much to the accuracy and meticulousness of Cheeseman. It seems that few specimens were properly labelled before his appointment in 1874. Cheeseman labelled newly acquired specimens but apparently did not begin to number them until 1898.

The earliest surviving departmental register (and numbering system) is the "Blue Book" (see Gill 1984). This lists New Zealand and foreign vertebrates specimens (including human material, but not fish), and was filled out by Cheeseman between 1898, when the book was manufactured, and 1917. Dates of receipt go back to 1870. In the column "When Received", many specimens are marked "In mus. 1874". Specimens were given simple consecutive numbers, and the suffix "V" (for vertebrates) was often used on specimen labels.

A later register (the "Brown Book"), for New Zealand mammals and birds, was filled out by Griffin between 1919 and 1922. The specimens are listed in systematic order, repeating many from the Blue Book. Simple consecutive numbers were used.

In January 1914 a museum-wide accessioning system was established whereby incoming objects received numbers of the form 198/37 (for the 198th object, or group of objects, received in 1937) with details recorded in a central bound register. Many older land vertebrates specimens have such numbers but the system was rarely used for land vertebrates after about 1980.

After Archey's appointment in 1924 the birds were catalogued or re-catalogued by Griffin using 5 x 3 inch ruled library cards. Birds were given AV numbers (e.g. AV 16.25 for the 25th specimen of the sixteenth species), and it was a "double card-index"—one copy was filed numerically and the other alphabetically by the Latin name. Griffin completed the birds in 1925-26. In 1941-42, Turbott extended the card index system to amphibians (AMPH series), reptiles (REP series) and mammals (MAM series)(Ann. Rep. 1941-42).

There was a numerical register of moa bones (with simple consecutive numbers), presumably started by Archey c. 1930, though few entries are in his hand. Cataloguing of moa bones along similar lines to the other birds (using the prefix MOA, e.g. MOA 6.13) was effected in 1966-67 by Wagener (Ann. Rep. 1966-67).

These departmental species numbering systems did not anticipate taxonomic changes. In the 1970s, Reed renumbered numerous specimens to try to accomodate revisions in the new checklist of New Zealand birds (Kinsky 1970), and to extend the cataloguing system to subspecies.

Largely to avoid this problem, the AV, MOA, REP, AMPH and MAM species numbering systems were abandoned in 1983-84 and three simple consecutive numbering series were begun: for birds (prefix B), herpetological specimens (prefix H) and non-cetacean mammals (prefix M). The new systems, starting at 1, were applied to new accessions and, as time permitted, existing specimens were checked and re-numbered (a final re-numbering, it was hoped).

In 1989-90 a computerised catalogue was set up on a stand-alone personal computer using the database software "Advanced Revelation" (Revelation Technologies Inc., Washington State, U.S.A.). By 1990-91 all H and M specimens (then numbering 1,400 and 500 respectively) had been checked, re-numbered and their main details computerised. Birds are still not completely re-numbered but the tally was 9,050 computerised specimens by June 1999.

LOCATION OF THE RESEARCH COLLECTION

Study-skins of birds must surely have been stored away from public view in the Princes Street museum, but all the mounts and perhaps most of the land vertebrates alcoholic collection would have been exhibited. After 40 years the Princes Street building, despite its extensions, was too small, and Cheeseman (1917) lamented the lack of space for new exhibits, existing exhibits "so crowded that they cannot be properly examined by visitors", the few facilities for scientific research, and the lack of storage for duplicate specimens intended for exchange. "Finally, the present workrooms [Fig. 3], though spacious enough, are badly lighted and insufficiently ventilated, and so damp that, with the exception of minerals, no specimens can be stored therein without grave risk of injury" (Cheeseman 1917).

Only with the move to the 1929 building was a separation achieved between research collections in storage and selected specimens on display (Powell 1967: 39). However, new and proper storage furniture was beyond the museum's means. Instead, glass-fronted exhibition cases from the Princes Street building had to be modified as storage cabinets for use by several departments (Ann. Rep. 1927-28: 9). The bird skins were stored on two sizes of wooden trays in recycled cupboards, including old display cases with the glass painted out. (These continued in use until 1991, though supplemented by some skin cabinets, with a third size of wooden tray, built specially c. 1960.)

In the 1929 building the rear (administration) entrance was on the ground floor near the west door of the present extended building. From the 1930s to the 1950s the Assistant Zoologist (later Ornithologist/Entomologist) occupied an office near the administration entrance (E.G. Turbott, pers. comm. 1992). The land vertebrates, and other zoological, collections were stored close by.

After Japan entered the Second World War and the Japanese Army advanced ever closer in New Zealand's direction "... normal routine was subordinated to the packing for removal to places of safety of representative collections ... [including] the whole of the spirit material" (Ann. Rep. 1941-42). Underground storage was provided in lava caves on private property at the foot of Mt Eden in a nearby suburb (E.G. Turbott, pers. comm. 1997). The collections were returned to the museum building in 1943-44 when there was "much to be done to bring the study collections back to their previous order and accessibility", a task hindered by the absence of staff on war service (Ann. Rep. 1943-44).

Until the 1960s, Archey's moa bone collection was stored in a small room over a disused lift

shaft in the north-west corner of the museum (second floor galleries). Archey often worked at night on the bones, sometimes until 2 a.m. (E.G. Turbott, pers. comm. 1997).

Commencement of the 1960 extension necessitated demolition of store-rooms on the ground floor at the rear, and the natural history reference collections were moved to first floor display halls at the front of the building (Ann. Reps. 1956-57, 1957-58). In due course the land vertebrates office and collection store were relocated to the first floor of the new curved administrative block at the rear of the building (south-east corner). The new store was dimly lit by a few incandescent bulbs and calico curtains covered the windows to exclude light. The study-skins were stored in three styles of cabinet each with its own tray-size; the moa bones in wooden trays on wooden racks open to dust.

In 1990-91 the first floor of the administration part of the 1960 extension was refurbished. The land vertebrates collection was moved temporarily to a closed-off portion of the Cheeseman Hall. The new land vertebrates collection store was provided with generous fluorescent lighting, forced air-circulation and internal insulated shutters or venetian blinds on the windows. It was in the same general location as before, but smaller, though its capacity was increased by use of mobile compacting storage units. The 1960s skin cabinets from the old store were reused and new units built to match, thereby standardising on one size of skin-tray. In subsequent years the moa bones were cleaned, and stored in lidded boxes on open steel shelves.

DISPLAYS 1852-1928

DISPLAYS BEFORE 1876

Little can be deduced about land vertebrates exhibits in the three buildings occupied by the museum before 1876. The museum's "Journal" (accessions register; see Park 1999), with its first entry for 3 July 1852, shows that six "glass cases" containing stuffed local birds were donated that year. The species included red-crowned parakeet, New Zealand pigeon, kokako, tui, long-tailed cuckoo, New Zealand kingfisher, fantail and whitehead. The first mammals mentioned in the register were a rat and mole from California (1852); the first herpetological specimen, a native frog (*Leiopelma*) from Coromandel (1853). These were presumably exhibited.

Birds were in demand: "The collection of native birds is a constant source of interest, and the [museum's governing] Council solicits the assistance of the country members [of the Auckland Institute] towards making it as complete as possible" (Ann. Rep. 1872-73: 7). Some of the early exhibits did not last long. When E.B. Dickson became Honorary Curator in 1859, one of his first acts was "the removal and condemnation of several specimens of birds &c., which had decayed beyond all remedy" (Park 1999).

Lists of new accessions in the museum's annual reports suggest that the following were among the objects exhibited before 1876: rock slabs showing moa footprints; moa bones and an articulated moa skeleton; several hundred bird skins from New Zealand, Australia, North America, India and Europe; various nests and eggs of local birds; 20 casts of New Zealand marine reptile fossils; various local and Pacific Islands reptiles in spirit.

DISPLAYS IN THE PRINCES STREET BUILDING

Completion of a purpose-built museum in 1876 (Fig. 1) transformed the possibilities for display (Figs 5-7). There was a single exhibition hall (later called the "Main Hall"), with an upstairs gallery occupying four sides around a central void. Illumination was initially by natural light from a skylight in the ceiling (Fig. 6); gas lighting was installed later. However, growth of the

collections was such that display space was always limited in the Princes Street building despite extensions. There was little storage space for duplicate material and "practically everything in the old museum had to be crammed into the cases in the exhibition galleries" (Powell 1967: 39).

Among the first land vertebrates exhibited in the new museum were foreign birds and mammals exchanged with Otago Museum, New Zealand birds and a skeleton of *Rhea americana* exchanged with Canterbury Museum, and 100 birds from New Ireland and New Britain purchased from the Rev. G. Brown. However, "from the want of new cases and other requisites, it has not been possible to display some of the specimens in as full a manner as could be wished" (Ann. Rep. 1876-77: 10). Photographs of this gallery before adjoining halls were added (Fig. 5; see also Powell 1967: 17) show jumbled and tightly-packed displays, with articulated skeletons, zoological wet specimens in display jars, and deer antlers, all juxtaposed with Maori carvings and plaster copies of classical statues.

By 1886 there were signs of attempts to go beyond individual animals in glass cases, when installation was completed of "a special group, showing the nature of the habitat and special surroundings of the Tuatara Lizard (*Sphenodon*), and a similar one of the Kea Parrot" (Ann. Rep. 1886-87). The first contained four or five tuataras, two sooty shearwaters and a diving petrel (details in "Blue Book"). The reptiles were collected by C.F. Adams on Karewa Island,

Fig. 5. Main Hall, Princes Street building, sometime between 1880 and 1892. The giraffe skeleton competes for attention with plaster copies of classical statues and a carved Maori store house. Stuffed birds are visible in the cases along the wall and the jars on the table-top display unit in the foreground contain natural history specimens in alcohol. (Auckland Museum Library, C27677.)

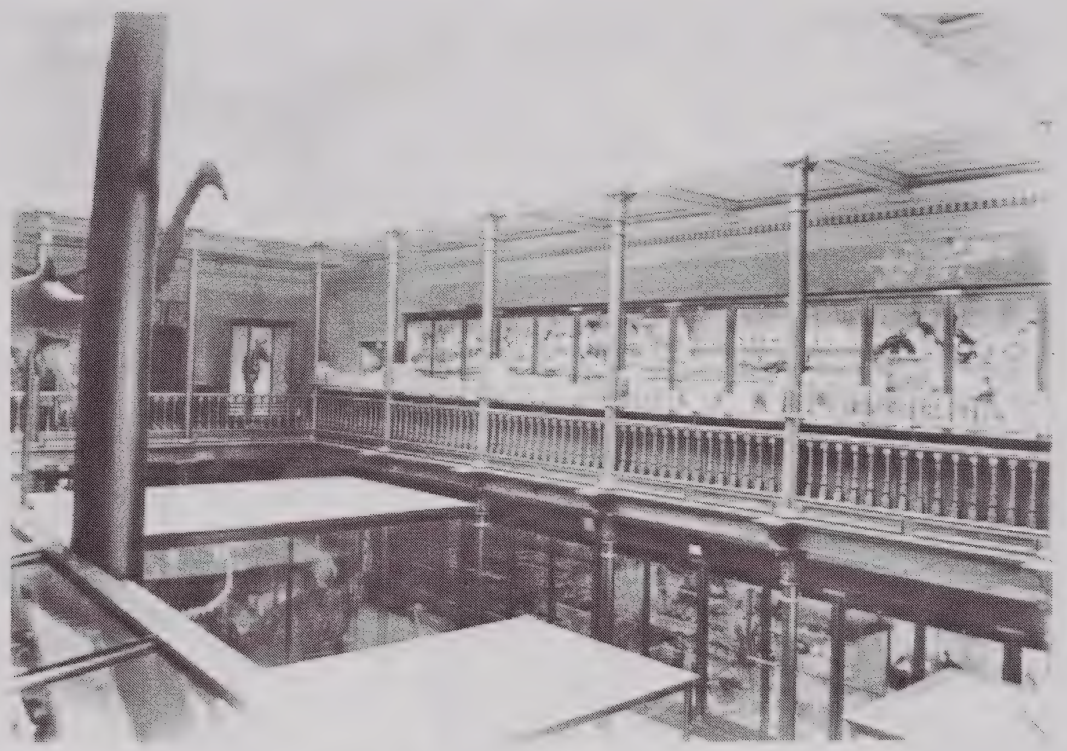


Fig. 6. Upstairs gallery of Main Hall, Princes Street building, 1928. A large skylight in the roof admits natural light. Birds occupy the wall cases of both levels. The ratite display is visible on the ground level. There is a row of specimens in alcohol above the railing, protected by wire mesh from toppling into the void. The horse's head in a case at the far end is that of the racehorse "Carbine". (Auckland Museum Library, C41106.)

Bay of Plenty. The keas, collected in Otago, were depicted attacking a lamb. Wolfe (1998) reproduced a photograph of what is probably the kea display and attributed its painted background to Kennett Watkins, who was associated with the museum at this time. In the same style, a small Auckland Museum display containing a family group of wekas (native rails) with foliage and a painted background is figured by Harper (1900: 99). This is probably the group of two adults and five young collected at Waikato and mounted and presented by F.H. Combes in 1886 ("Blue Book"). The tuatara and weka dioramas are just visible in the background of Fig. 10.

In 1890-91 the Bornean mammals purchased from (and "elegantly mounted" by) C.F. Adams were "placed in a new show case specially erected for them in the centre of the Museum Hall" (Ann. Rep. 1890-91: 7). In October 1892 a gallery ("Ethnological Hall") was opened off the Main Hall and the Maori and other ethnographic collections were moved into it making more room for natural history in the Main Hall. The taxonomic groups of mammals and foreign birds were rearranged and given "printed descriptive labels, accompanied with maps showing their geographical distribution" (Ann. Rep. 1893-94). In the same year a case was set up displaying "complete sets of the leg-bones of several of the species" of moas.

A third hall ("Statue Hall") was opened in October 1897 to contain the plaster copies of

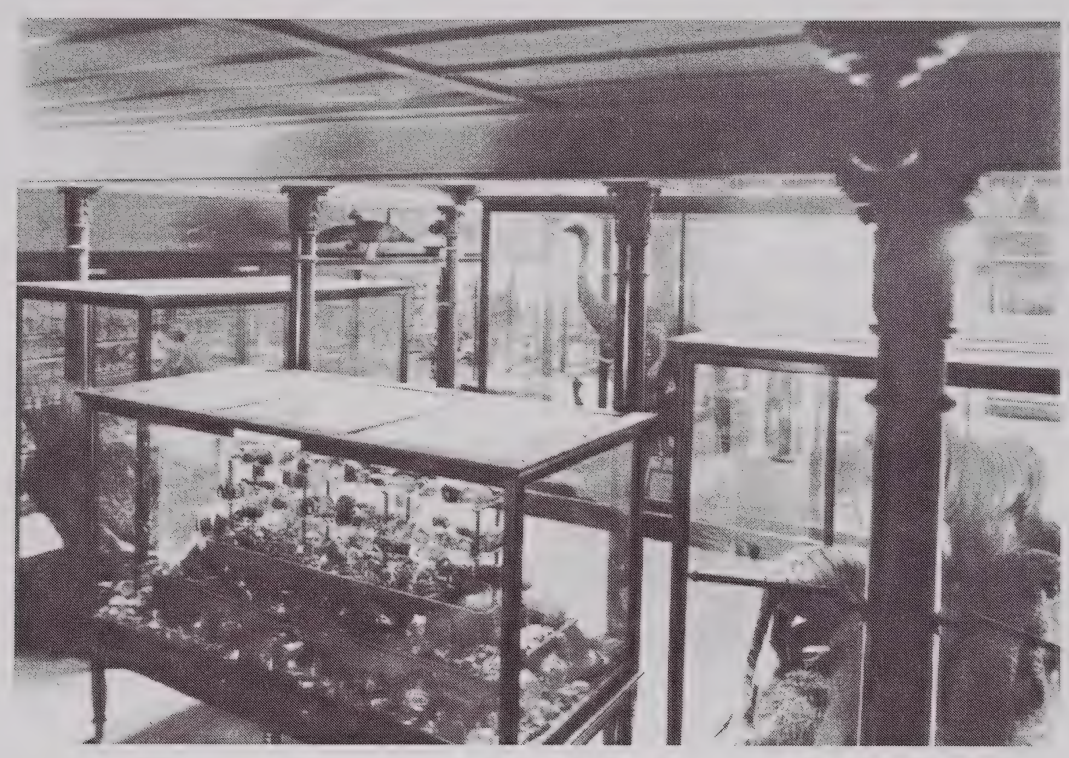


Fig. 7. Ground level of Main Hall, Princes Street building, 1928. The hall is now devoted entirely to natural history. Birds occupy the wall cases to the left. The free-standing cases contain (from left to right): the Gerrard & Sons lion group, kauri gum, the ratite display with moa reconstruction and the Gerrard & Sons tiger/leopard group. (Auckland Museum Library, C41107.)

classical statues, hitherto displayed in the Main Hall, and to serve as a meeting room. This meant that the Main Hall could be devoted entirely to natural history. A plan was devised to fill the centre of the hall progressively with "groups of the larger mammals, arranged in suitable glass cases" (Ann. Rep. 1896-97), additions which "more than any other would enhance the appearance of the Museum, and add to its value as a means of recreation to the general public" (Ann. Rep. 1899-1900).

In 1905 an annex to the Ethnographic Hall was completed for the better accommodation of the Maori collections and to provide for erection of a carved meeting house. In 1904 (or 1905) the first of the long-anticipated large mammal display groups was received, paid for by the Mackechnie bequest. These groups "attracted considerable attention, and are no doubt responsible for a large proportion of the increased number of visitors to the Museum [61,000 for the year]" (Ann. Rep. 1905-06).

To make room for the large plate-glass cases containing the mammal groups, the alcoholic specimens had to be moved upstairs to the gallery. New glass jars were imported and "shelving, with wire guards" provided (Ann. Rep. 1906-07; Fig. 6). In 1909-10 some of the alcoholic specimens were remounted in rectangular glass jars imported from London.

In 1912 there was further progress towards display dioramas when a large group of pied shags (*Phalacrocorax varius*) was prepared with a painted background. An attempt was made to

"show a small colony of the bird in its usual breeding habitat of the upper branches of the pohutukawa tree, the nests, eggs, young, and several examples of both sexes in the adult stage" (Ann. Rep. 1912-13). Two years later a similar group illustrating the spotted shag (*Stictocarbo punctatus*) was installed (Ann. Rep. 1914-15; Fig. 8). This group, containing adults in breeding

Fig. 8. Habitat group of spotted shags *Stictocarbo punctatus* completed 1914-15. (Auckland Museum Library.)

plumage, nests, eggs and chicks was an "exact representation" of a part of the breeding colony at Shag Rock, Firth of Thames. The specimens were collected and mounted by Griffin and the "well-known artist Mr. Kennett Watkins" painted the background. These were followed by cases exhibiting habitat groups of brown kiwis (*Apteryx australis*; Ann. Rep. 1915-16; Fig. 9) and white-fronted terns (*Sterna striata*; Ann. Rep. 1918-19; Fig. 10).

In 1916 the mineral collection was moved, freeing the gallery of the Main Hall to be devoted entirely to New Zealand animals including birds (Ann. Rep. 1916-17). However, space was still limited: "... a glance at the show-cases containing the New Zealand birds will prove that no space remains for further additions. The preparation of special groups illustrating the

Fig. 9. Habitat group of brown kiwis *Apteryx australis* completed 1915-16. (Auckland Museum Library.)

Fig. 10. Habitat group of white-fronted terns *Sterna striata*, c. 1920. This case, completed 1918-19, is in the upstairs gallery of the Main Hall and its label is headed "Group illustrating the breeding habits of the Black-headed Tern (*Sterna frontalis*)." Behind the tern case to the right is visible the kiwi habitat group; the two small cases to the left appear to be the pre-1900 displays of tuataras (below) and wekas (above). (Auckland Museum Library, C27027.)

life history of New Zealand birds, which have proved to be such popular exhibits, has had to be suspended, there being no available space in which to place the show-cases" (Ann. Rep. 1918-19).

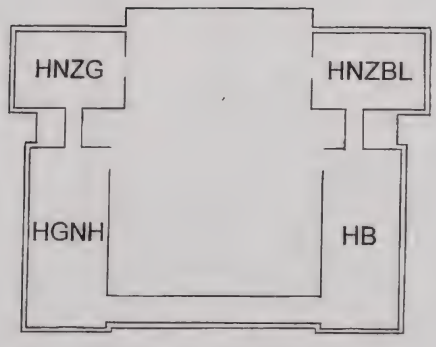
In 1928, the exhibits at Princes Street were dismantled for removal to the new building (Ann. Rep. 1928-29: 7; Powell 1967: 40).

DISPLAYS 1929-1960

HALL OF NEW ZEALAND BIRD LIFE

In 1928 and 1929 the new building in the Domain began to be occupied, and a hall of New Zealand birds was developed in stages in the north-east gallery on the first floor (Figs 11, 13; later the English Furniture Hall, and currently under redevelopment). A display of New Zealand birds was in place there at the museum's opening in November 1929, but the gallery was constantly added to and refined during subsequent decades. The gallery was lit by natural daylight from windows on the north and south walls, and many stuffed birds suffered serious fading as a result.

The pied shag, spotted shag and kiwi habitat groups from Princes Street were installed along the east wall of the gallery (E.G. Turbott, pers. comm. 1998), and new groups were developed. "The plan of displaying native birds in groups representing their natural habitat is



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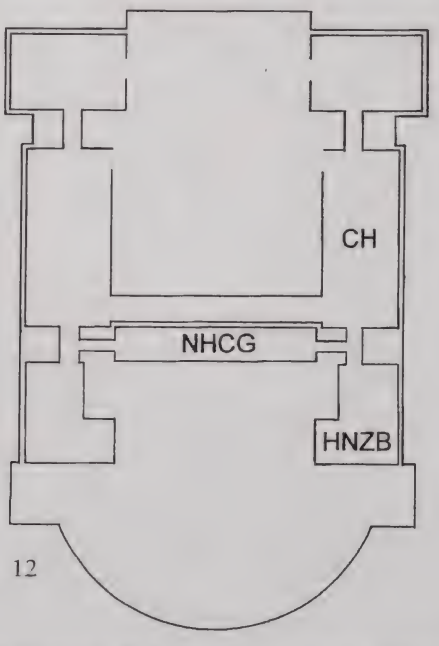

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Figs 11-12. Gallery floor plans (first floor only) showing disposition of galleries containing land vertebrates exhibits, plus the Hall of Botany (HB), renamed Cheeseman Hall (CH) in 1946 (Ann. Rep. 1946-47: 6). North at top of page. 11. 1929 building, for period 1930-60. HNZG = Hall of New Zealand Geology, HNZBL = Hall of New Zealand Bird Life, HGNH = Hall of General Natural History. 12. Extended building, for period 1975-95. NHCG = Natural History Cross Gallery, HNZB = Hall of New Zealand Birds.

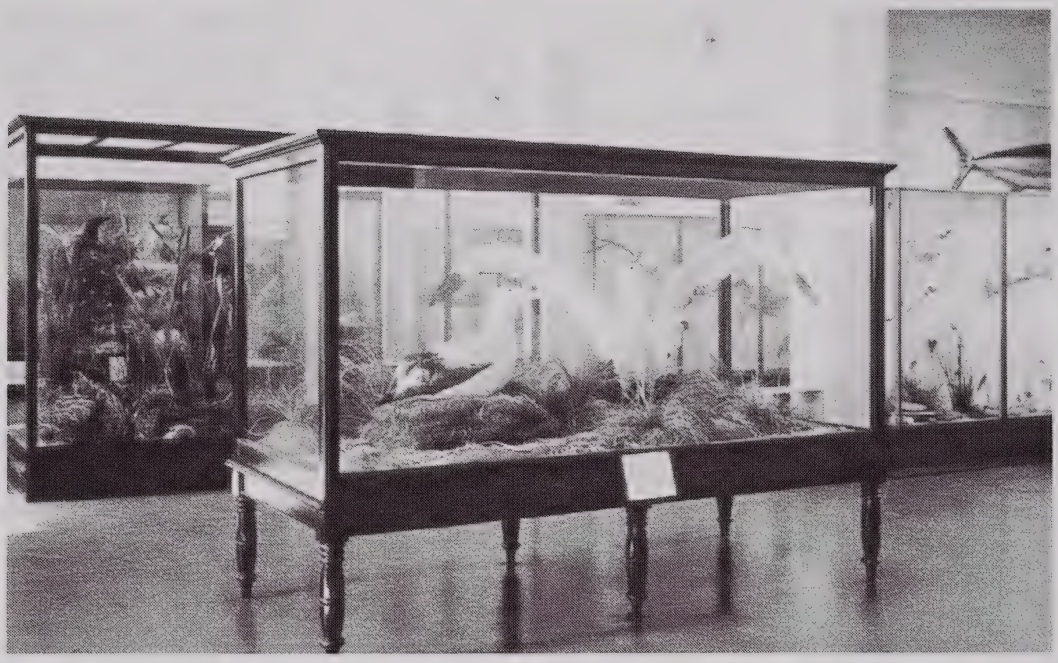

Fig. 13. General view of 1929 Bird Hall, c. 1960. "A new habitat group, illustrating the courtship and nuptial display of the Wandering Albatross, has now been placed centrally in the New Zealand Bird Hall" (Ann. Rep. 1932-33: 19). Photo: E.G. Turbott.

being followed as far as the size of the show cases will allow. A group of gannets has been completed ..." (Ann. Rep. 1930-31).

Many of the specimens for the new displays were shot locally by Falla, and prepared by Dover—thus the museum was able to display many fresh and well-prepared specimens, which have been used again in later displays. In 1931-32 subantarctic and antarctic habitat groups were added, as well as 50 further individual mounted birds, some of them replacing faded specimens.

In 1933-34 an introductory case was added "in four sections to illustrate bird structure, flight, migration, and flightlessness" (Ann. Rep. 1933-34). Also that year a habitat group of keas was completed, "the accessory vegetation having been collected by Mr W. Martin from kea country in Marlborough". In 1937-38 was added "a habitat group of New Zealand inland water birds" mounted by Dover. In new displays of terns, gulls, albatrosses and petrels, a "satisfactory result" was obtained from "a formal arrangement against a uniform background with a rock or sand base" (Ann. Rep. 1938-39). Six new cases were finished in 1939-40 illustrating forest birds, pasture birds, birds of waste and cultivated land, some taxonomic groups and introduced birds. In 1940-41, cases of parrots, penguins and kiwis were finished, so completing the general displays of New Zealand birds. In the same year, there were experiments with artificial lighting in the deeper cases containing habitat displays (Ann. Rep. 1940-41). Type-written labels were progressively replaced with printed labels in more legible type (Ann. Rep. 1946-47).

In about 1950 the power supply for displays was changed from direct to alternating current permitting use of fluorescent lighting for the first time (Ann. Rep. 1951-52: 13). In 1950-51 "a

newly arranged habitat group of godwits and other waders" was installed with a new painted background (Ann. Rep. 1950-51). This was a "special display project" using internal strip lighting to illuminate the case. In 1952-53 some "formal" cases in the gallery were replaced by six new habitat groups, again illuminated by strip lighting, and artificial lighting was extended to other cases. "An effective representation of the habitat in this shallow type of case proved a difficult problem, but has been overcome by Mr. McCaw in the blending of his painted background and foreground material on a gently rising base" (Ann. Rep. 1952-53).

The 1929 bird gallery remained intact until about 1969 when work began on a new bird hall elsewhere on the same floor.

HALL OF GENERAL NATURAL HISTORY

The 1929 building contained a Hall of General (or Foreign) Natural History, in the largest gallery on the west side of the first floor (Fig. 11). The display-groups of foreign mammals from the Princes Street building were re-erected here (Ann. Rep. 1928-29: 14). Dover mounted

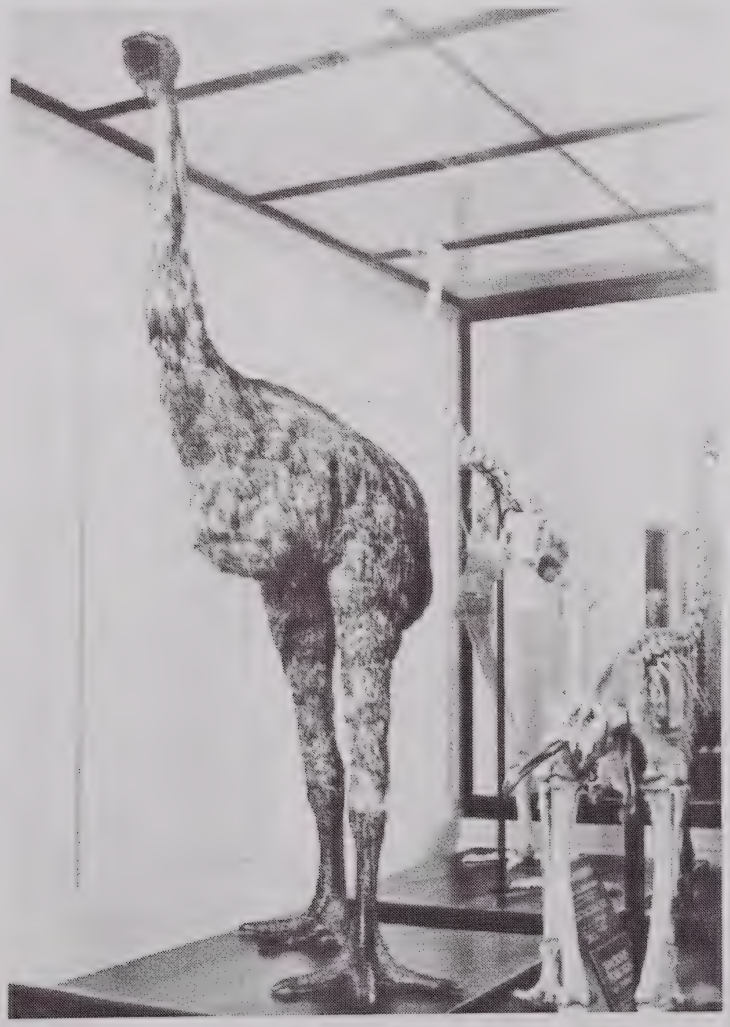

Fig. 14. Moa display in the Hall of New Zealand Geology, 1937. (Auckland Museum Library, C41105).

a kudu and wildebeeste that died at Auckland Zoo, and "mounted in a habitat case a fine pair of introduced [red] deer" (Ann. Rep. 1932-33: 15). In this gallery were displayed mounted heads of Canadian mammals (Ann. Rep. 1934-35) and the museum's large collection of foreign mounted birds. The annual report for 1935-36 refers to a new arrangement of birds of paradise in this gallery and a "natural habitat group of pheasants". The Indian elephant "Rajah", mounted by Dover (Fig. 4), was exhibited in this gallery from October 1936. In 1942-43 a habitat group of monkeys was installed including four new specimens mounted by Dover. A display of Australian animals from Kawau Island was also installed (Ann. Rep. 1947-48).

With the rearrangements following from the additional galleries in the 1960 extension, the Hall of General Natural History became the Geology Hall, and is currently the Oceans Gallery.

HALL OF NEW ZEALAND GEOLOGY

This gallery on the north-west corner of the first floor (Fig. 11) held a display of moas (Fig. 14) and of foreign ratite birds. After 1960 it became the Maritime Hall, and is now the Human Impacts Gallery.

DISPLAYS AFTER THE 1960 EXTENSION

HALL OF NEW ZEALAND BIRDS

Although the extension to the 1929 building was completed in 1960, work did not begin on the new bird hall in the extension (first floor galleries south-east; Figs 12, 15-17) until about 1969 with opening in 1972. Donations for the fitting out of the new bird gallery were received from the Sir John Logan Campbell Trust ($14,300) and the Auckland Savings Bank ($7,000) (Ann. Reps. 1971-72, 1972-73, 1973-74). Turbott, then Director, planned the contents and wrote the labels. Cappel, the museum's Preparator, helped develop the floor plan and produced the identification displays and dioramas. Windows in the gallery were covered and illumination was by fluorescent lighting.

The first item to be completed was the wandering albatross diorama at the entrance to the hall (Fig. 15), installed by 1969-70, and re-using birds from a 1933 display (Fig. 13). The main part of the gallery (300 m^2) was opened to the public in April 1972 by Sir Arthur Galsworthy, British High Commissioner to New Zealand. At opening, six of the dioramas and three cases remained to be finished. The Little Barrier diorama (Figs 15, 16) was completed in December 1974, and the last diorama (gannet nesting group) in 1975-76.

When complete, the 1972 bird hall contained some 470 mounted birds. There were four main sections dealing respectively with sea birds, forest birds, birds of town and country (plus extinct birds), and shore and swamp birds (Fig. 15). For each of the main taxonomic groups (penguins, oceanic birds, shags, gulls and terns, ducks, waders) and habitats (forest, town and country, mountain and open country, freshwaters) there was an "identification series" comprising mounted examples of nearly every New Zealand species. These were grouped mostly on painted supports against plain painted backgrounds.

Spread throughout the hall were 12 dioramas both large and small (Fig. 15). Most had fully domed backdrops. The hall's "feature diorama" showed forest birds on a dry kauri ridge on Little Barrier Island. It comprised the carefully modelled ridge features, including representations of tree trunks and dense foliage, in front of a large painted plaster dome. Looking to the left past the birds and foliage could be seen the Hen and Chicken Islands on the horizon. In the wader deep dome the careful painting of the curved backdrop created the illusion, in a confined

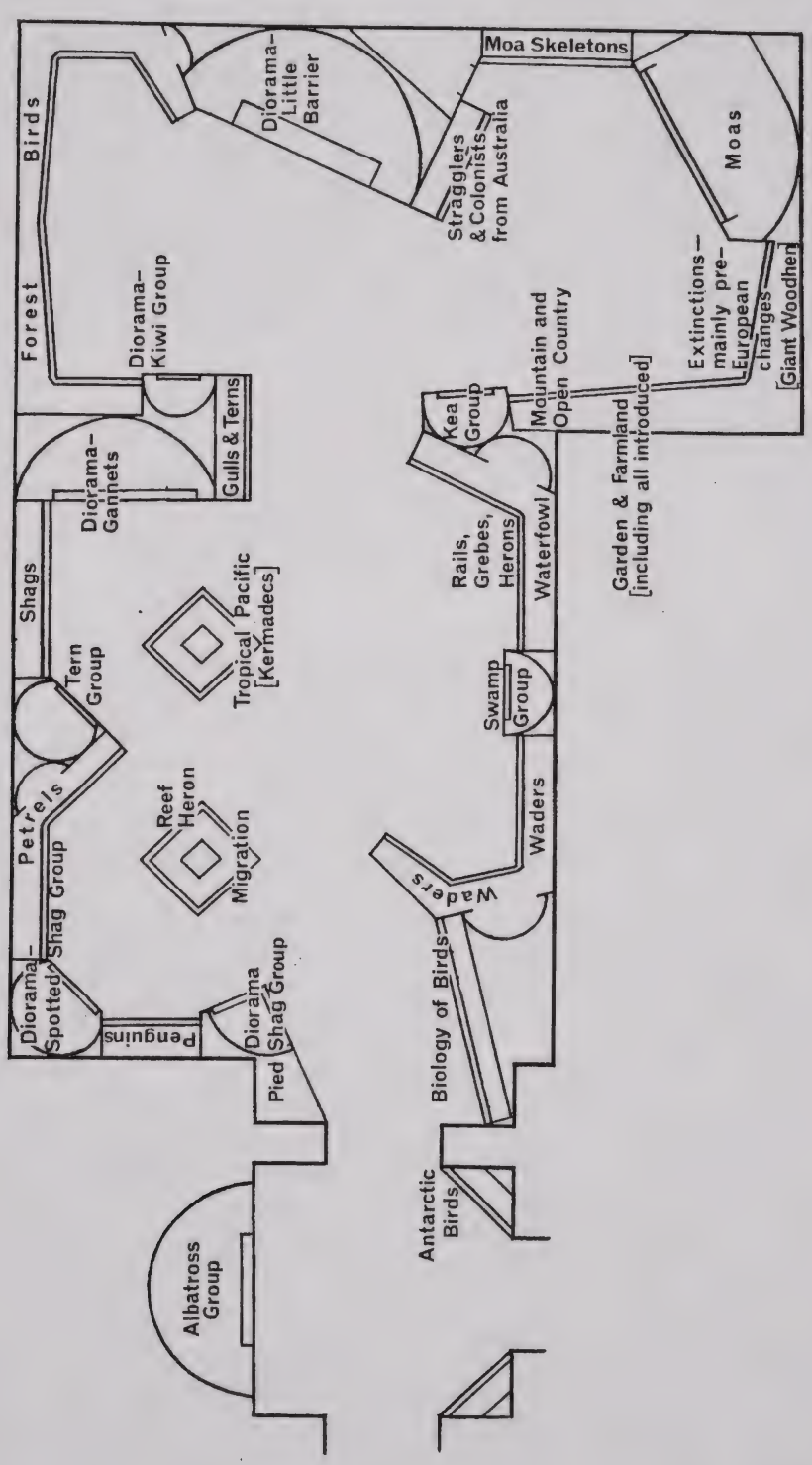

Fig.15. Floor plan of Hall of New Zealand Birds showing disposition of exhibits, 1972-96. Diagram: S. Ensor.

space, of a limitless horizon. An innovation by Cappel in the swamp scene inset (back-to-back with the kea group, Fig. 15) was painted foliage on a fine gauze screen to create a middle-distance and an illusory depth of field (Ann. Rep. 1972-73).

Most of the dioramas—albatross, pied shag, spotted shag, tern, kiwi, kea, swamp scene inset, and swamp (inland waters) group—were modifications of "habitat groups" from the 1929 bird hall. The gannet colony, Little Barrier diorama, backdrop to the old moa reconstruction (Fig. 17) and wader deep dome were new. Most of the mounted birds throughout the hall were reused from previous displays. At opening, the white-fronted tern diorama had sound effects—tape-recorded bird calls activated by push-button. Sound was later added to the kiwi and Little Barrier dioramas.

The cases in the 1972 bird hall had steel-framed plate glass fronts with wooden floors, backs and partitions. The glass fronts were hinged above for access. Fluorescent strip lighting above each case was concealed behind a hinged wooden access-flap. Labels were hand-written by a staff artist, with main headings in cork lettering. The displays were broken up in 1996, and the gallery redeveloped for collection storage.

NATURAL HISTORY CROSS GALLERY

A long, narrow gallery linking east and west display galleries on the first floor of the 1960 extension (Fig. 12) was developed as a hall of foreign natural history in the 1960s. The east wing contained most of the museum's old collection of foreign birds mounted on individual bases (Fig. 18). These were grouped taxonomically in bronze-framed glass cases (manufactured

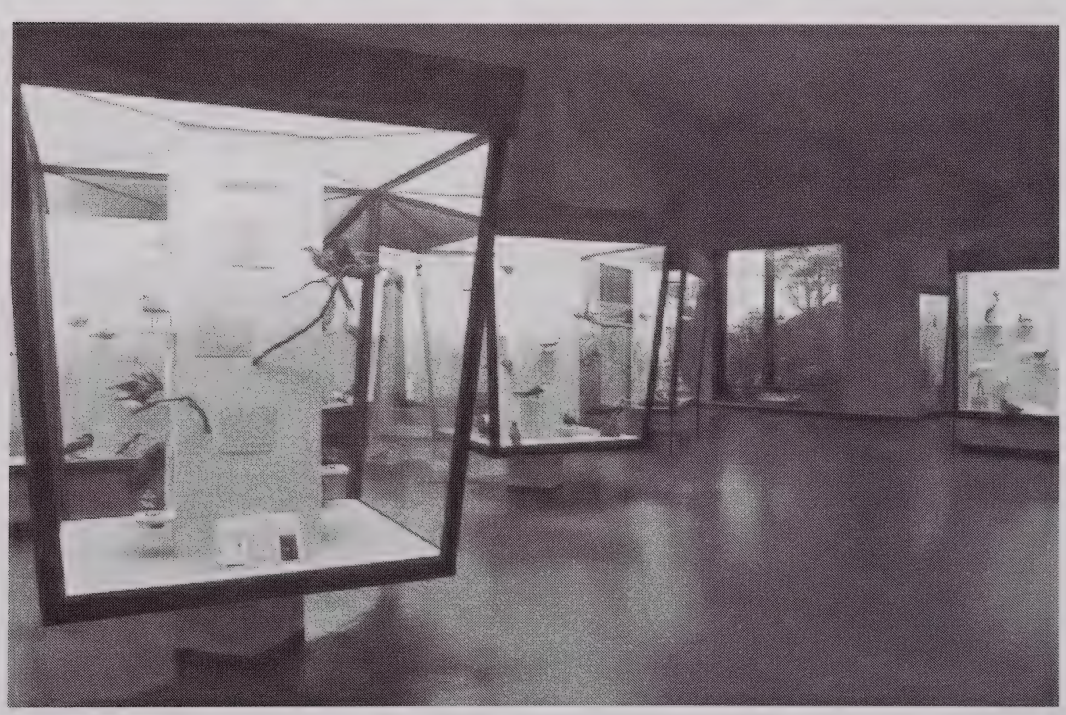

Fig. 16. Hall of New Zealand Birds, 1996. View from near the entrance looking towards the Little Barrier diorama in the distance. Two free-standing cases on the left deal with migration and subtropical seabirds. Photo: K. Pfeiffer.

Fig. 17. Hall of New Zealand Birds, showing the moa reconstruction, a group of four moa skeletons and a case of other extinct birds, 1996. Photo: K. Pfeiffer.

Fig. 18. Foreign birds in the Natural History Cross Gallery, 1994. The birds of paradise in the foreground are a 1972 rearrangement in an older case; the other birds are in recycled brass cases from the original 1929 displays. Photo: K. Pfeiffer.

by A. Edmonds & Co. Ltd. of London and Birmingham) recycled from the original 1929 displays. The west wing contained foreign mammals mostly regrouped from earlier displays, in particular the 1906 musk oxen and polar bear group, and later groups containing primates, kudu and gnu, red deer, and seals. Two cases developed after 1969 showed representative foreign mammals and mammals introduced to New Zealand. Between the two wings an elevated area held the Hemingway collection of foreign insects. The gallery was closed in 1994 and redeveloped as a natural history "discovery centre" for children.

THE GREAT EXCHANGES, 1875-1905

Cheeseman corresponded prolifically with natural historians and collectors overseas, often seeking to exchange specimens (see Goulding 1974, 1975 and 1976 for details of botanical exchanges). "Arrangements have been made by the Curator for interchanges with most of the principal European Museums ... From the Paris Museum a first consignment has already arrived, comprising an extensive series of mammals, bird skins, &c. ... [and a] collection of bird skins has also been received in exchange from Mr D. S. Bryant, of San Francisco" (Ann. Rep. 1877-78: 10). In the 1883-84 year lack of storage space forced Cheeseman to "suspend the usual exchanges with foreign museums".

Cheeseman could offer for exchange skins of native New Zealand birds, including South Island species like yellowheads. Particularly large numbers of kiwi specimens were sent; also moa bones, tuataras and ethnographic items. In the 1878-79 fiscal year, the museum purchased 200 New Zealand bird "skins", "partly for exchange with foreign Museums" (Ann. Rep. 1878-79: 9). A gift of reptile specimens from Mr Parsons of Tonga was especially valuable "from the large number of duplicate specimens which will be useful for exchanges" (Ann. Rep. 1878-79: 10).

Exchanges of land vertebrates were made with New Zealand and foreign museums and with foreign dealers in natural history specimens (e.g. Garnier and Ward; see Appendix 1). The main exchanges took place during some 30 years between about 1875 and 1905. The major exchange partners in terms of numbers of land vertebrates specimens received were the Florence Museum (at least 635 specimens received), the Smithsonian (at least 343 specimens) and Dr Garnier (at least 326 specimens). Closer to home, more than 100 specimens each were received from the Australian Museum (Sydney) and Otago Museum (Dunedin).

An example of an exchange is that in 1881 with the natural history dealer H.A. Ward of Rochester, U.S.A., who in the course of his business helped enrich U.S. museums during the period of rapid development of popular museums in the 1870s and 1880s (Kohlstedt 1980). The stimulus for the exchange was presumably a visit to Auckland by Ward (Ann. Rep. 1881-82: 7).

Ward gave or sent Cheeseman a hand-written note dated 28 March 1881:

> I have this day received from Mr. T.F. Cheesman [*sic*] various specimens of Natural History valued at £55.10.0 (including 12 skins of Apteryx still to be sent me.) In exchange for these specimens I hereby agree to send to the Auckland Institute and Museum a certain series of Casts of Celebrated Fossils ammounting [*sic*] — [illegible] catalogue prices to $268.25 = £55.10.0. (List signed by me.) These casts I will if practicable send from Melbourne (Australia) about one month hence. Otherwise they will be sent from New York as soon after June 1st '81 as a ship may be leaving for Auckland. In either event the entire series of specimens will be carefully packed at my expense and delivered to the ship which is to bring them. [Signed] Henry A. Ward.

A list in Cheeseman's hand shows what he gave to Ward: 24 New Zealand bird skins; 17 kiwi skins, skeletons or eggs; a "moa track" (i.e. fossilised footprint/s); four geckos; a seal skull;

a whale skull; a hornbill; 15 bird skins and seven ethnographic items from Melanesia ("duplicates from Mr Goldie's New Guinea collections"); 47 Maori items (mainly stone implements); a specimen of ? (illegible); and a specimen of nickel.

An inventory in Cheeseman's writing, signed by Ward, shows the plaster casts that Ward sent in return: six skulls or framed slabs (showing exposed fossils *in situ*) of fossilised mammals (including skulls of Neanderthal man, *Mastodon* and *Diprotodon*); a tarsometatarsus and egg of the elephant bird (*Aepyornis*); seven framed slabs of fossilised reptiles (including ichthyosaurs and plesiosaurs); six framed slabs of fossilised fishes; nine invertebrate specimens; and examples of 96 species of Foraminifera. "The casts have lately arrived from New York, and the greater portion have just been placed in the Museum" (Ann. Rep. 1881-82: 7).

SPECTACULAR DISPLAY OBJECTS

MAMMALS OF THE MACKECHNIE BEQUEST

In 1902 the museum received a bequest from Mr E.A. Mackechnie, which included £500 for "procuring groups of the larger mammals and the necessary show-cases" (Cheeseman 1917). Four mammal groups were obtained, all prepared by Gerrard and Sons of London. The first group (male and female lion and four cubs) was placed in the Main Hall as soon as it arrived from England (Ann. Rep. 1904-05). A second group (male and female tigers and a leopard) followed in 1905 (Ann. Rep. 1905-06). The Arctic Group (polar bear and three musk oxen, male, female and young) arrived in 1906. This last group (and possibly others) was shipped to New Zealand free of charge by the Shaw Savill Line. The fourth and final group arrived in 1907—a group of South African mammals comprising a zebra, a waterbuck, a springbok and an impala (Ann. Rep. 1907-08).

All the groups were presumably moved to the 1929 building, but they were eventually broken up except for the Arctic Group. This was displayed in the Natural History Cross Gallery from the 1960s to 1994, then in the Cheeseman Hall where it remained on exhibition until 1997, after which it was stored off-site.

MOA RECONSTRUCTION AND GIANT MOA SKELETON

In 1912 a successful public appeal was made to raise £700 for the two-fold aim of purchasing some Maori carvings and setting up a plate-glass case containing a moa "restoration", a large moa skeleton, and mounted examples of various living ratites (Ann. Rep. 1911-12). In 1912 an articulated skeleton (comprising plaster casts) of the largest moa *Dinornis giganteus* (skeleton shown at rear of Fig. 14) was received from Mr Damon, an English dealer. L.T. Griffin built a reconstruction of the same species using emu feathers (Figs 14, 17). Both were 3 m tall. The ratite display was finished in 1913 and placed in the centre of the Main Hall (visible in Fig. 7). It was inaugurated by a conversazione on the evening of 8 October 1913 attended by about 550 people.

In the 1929 building, the moa reconstruction and giant moa skeleton were exhibited in the Hall of New Zealand Geology (Fig. 14). Both were prominent features of the 1972 Bird Hall (Fig. 17), the moa exhibits forming the museum's second most popular attraction after the Maori displays. The reconstruction was moved to the Special Exhibition Hall on the ground floor for a temporary exhibition ("Kiwi and Moa: Flightless Wonders") in the summer of 1991-92. With the closure of the Bird Hall in March 1996, the large skeleton was stored and the

reconstruction was moved to open display in the Cheeseman Hall. (In September 1997 the reconstruction was stored, and from early 1999 it was displayed in its own case as a major attraction in the new Origins Gallery in the Cheeseman Hall. The skeleton was displayed in late 1999 in an alcove near the west front stairs.)

"RAJAH" THE ELEPHANT

In March 1936 a young bull Asiatic elephant (*Elephas maximus*) named "Rajah" was shot at the Auckland Zoo because he was becoming hard to handle. He was 19 years old and had been bought for £100 in 1930 from Hobart Zoo. The skin was prepared for mounting at Auckland Museum by Dover—one of the biggest taxidermy jobs ever undertaken in New Zealand (Fig. 4). "Visitors were given opportunities of witnessing the various stages in this undertaking, which aroused almost as much interest as the complete preparation" (Ann. Rep. 1936-37). The prepared specimen was exhibited in October 1936 in the Hall of General Natural History. "Rajah" remained in the centre of this gallery until 1992 when he was moved to the ground floor and exhibited on a raised platform in the foyer. In March 1994 "Rajah" was removed to an off-site store after 58 years of constant exhibition. (In 1999, "Rajah" was brought back to the museum to be restored for display in a social history gallery.)

EARLIEST SPECIMENS

BIRDS

The oldest bird in the Auckland Museum collection is a study-skin of a grasshopper warbler *Locustella naevia* (B7633) collected in England in 1844, but obviously obtained by the museum later. The oldest New Zealand ornithological specimens are fragments of moa eggshell collected

Fig. 19. Mounted specimen of the extinct New Zealand quail *Coturnix novaezelandiae*, prepared by I. St John of Nelson and received by the museum 1856-57. It is one of the museum's earliest surviving acquisitions. Photo: B. Gill.

by W.B.D. Mantell in 1847-8 (B4013) and 1852 (B4014), but it is not known when the museum received them.

The museum's oldest surviving stuffed birds are those bought from the collector and taxidermist I. St John of Nelson in 1856-57, which are among the very few items known to have been in the museum's collection before its move to the Princes Street building. The museum's "Journal" lists 35 birds in two lots received on 8 September and 12 December 1856. A third consignment received on 16 January 1857 is not itemised. Only 13 St John birds survived to be registered by Cheeseman in the "Blue Book". Of these, five can be identified in the collection today: relaxed mount of New Zealand falcon (B2521, Blue Book 837); mount of New Zealand quail (B4106, Blue Book 842, Fig. 19); mount of orange-fronted parakeet *Cyanoramphus malherbi (= auriceps)* (B4179, Blue Book 815 or 816); relaxed mount of yellowhead (B4852, Blue Book 766 or 767); and mount of New Zealand robin (B8480, Blue Book 748). A possible sixth St John bird is B7869, relaxed mount of *Cyanoramphus malherbi.*

The next oldest surviving New Zealand birds, received in 1870, are a mounted brown kiwi (B8590) and a mounted New Zealand snipe *Coenocorypha aucklandica* (AV 1389.1).

REPTILES AND AMPHIBIANS

The oldest herpetological specimen is a shore skink *Oligosoma smithi* in alcohol (H613) collected in the Bay of Islands in 1841 by the Royal Navy Antarctic Expedition (*Erebus* and *Terror*). It was obtained by exchange from the British Museum (Natural History) in 1983.

A sea snake *Pelamis platurus* that came ashore alive c. 1868 just south of Port Waikato is possibly H335. Cheeseman (1908) described its capture:

> It was discovered by some Maoris, who were naturally afraid to touch it, but with some little trouble managed to guide it into a discarded Wellington boot. They then took it to Mr. Dashwood, the proprietor of the store at Port Waikato, who secured the specimen, sacrificing the better part of a bottle of whisky for its preservation. A few months later he gave it to the late Captain Hutton, by whom it was presented to the Auckland Museum, where it still exists. Many years after the capture of the specimen the late Mr. Dashwood gave me a graphic account of the consternation which its arrival created among the Maoris, who were inclined to regard it as a juvenile *taniwha* [mythical monster].

No tuatara or lizard specimens survive in the collection from the 1800s. The oldest specimen exchanged before 1900 is a skeleton of *Python sebae* (H644) received from the Paris Natural History Museum in 1878.

MAMMALS

Antelope bones (M362) from Ethiopia collected in 1870 and received in 1887 are the museum's earliest surviving mammalian specimen. The oldest New Zealand mammals are a long-tailed bat *Chalinolobus tuberculatus* (M59) and lesser short-tailed bat *Mystacina tuberculata* (M15), purchased together in 1890.

DISCUSSION

Two dates, 1876 and 1929, stand out as major milestones in the early development of Auckland Museum and its land vertebrates collection. In 1876, two years after the appointment of Thomas Cheeseman, the museum at last settled into a large purpose-built building, and could develop attractive exhibits and expand the collection. During the Cheeseman era of almost 50 years the

museum became established as "one of the chief scientific institutions in New Zealand" (Cheeseman 1917), and Cheeseman promoted exhibits, collections and research with vigour.

The move to a new building in 1929 signalled the further expansion of the museum on all fronts. There was room to separate objects for exhibition from those to be held in storage for reference only. The complement of staff increased beyond a curator and assistant so that collections began to be curated by specialists—in 1930 there was a Conchologist/Palaeontologist (A.W.B. Powell), a Botanist (Lucy Cranwell) and an Honorary Ornithologist (R.A. Falla). Also in 1930 the museum began annual publication of a scholarly periodical, *Records of the Auckland Institute and Museum* (see Furey & Gill 1997).

Auckland Museum has always been funded predominantly by the local community. The Princes Street building, 1929 building and 1960 extension, were all largely paid for by public subscription, with limited contributions from the New Zealand Government (see Powell 1967). A characteristic of Auckland Museum has been the continuous strong support by local citizens, particularly members of the "Institute", which has functioned, among other things, as a "Friends of the Museum" group since 1867. Gifts of objects for the collection, and small monetary donations have been numerous. However, a dearth of major private benefactors, and minimal financial support from the New Zealand Government, meant that Auckland Museum has been chronically short of funds for much of its existence. To give one example of the impact of this on the land vertebrates collection: apart from some small waist-high cabinets with drawers at each end, that may have been used for bird study-skins before 1929, no proper skin cabinets were provided for the bird collection until about 1960, and then only as an adjunct to inferior cabinets that were not replaced until 1991.

Further to the question of government support, it is worth noting that the land vertebrates collection at Auckland Museum, as at other New Zealand museums, never benefited from systematic government-funded collecting as occurred with official faunal surveys in countries like the United States of America and India. An exception perhaps is the bird collection of the B.A.N.Z.A.R. Expedition (Appendix 1). Instead, some of the finest sub-collections of land vertebrates at Auckland Museum were gifts from individuals who had collected at their own expense—the Buddle and McLean collections of New Zealand bird eggs, and the Hughes, McGregor, Munro and Pycroft foreign collections (Appendix 1).

For small colonial museums with limited funds, the great exchanges in the last quarter of the 1800s were a practical way of widening the scope of the collections. New Zealand museums, with a novel fauna and desirable Maori ethnographic items at hand, were ideally placed to attract good exchanges, and Auckland Museum seems to have had some success with exchanges for land vertebrates. However, needs and wishes were seldom easy to meet, as shown by the problems associated with Canterbury Museum's exchanges, including a world-wide glut of kiwi specimens and moa bones (Sheets-Pyenson 1988). The aim in acquiring foreign natural history specimens was to build up a "type" collection illustrating the world's main animal and plant groups. By exhibiting exotic species from around the world, Cheeseman was contributing to the entertainment and education of the people of Auckland at a time when there was no local zoo and books illustrated in colour were scarce.

Cheeseman must have welcomed the occasional visit to Auckland by foreign experts as a source of new ideas complementary to his prolific correspondence with curators and scientists around the world. One such foreign expert was the entrepreneurial American collector and dealer Henry Ward, who visited Auckland and in 1881 exchanged specimens with the museum. Ward was always ready to give "advice on preparation, preservation and presentation to inexperienced directors of understaffed new museums" (Kohlstedt 1980). His assistance to Auckland Museum continued after his visit—about 1884 he acted as the museum's agent in

the selection of an American taxidermist prepared to emigrate to Auckland.

Ward's visit may also have been influential in the genesis of Auckland Museum's first habitat displays—the small tuatara, kea and weka exhibits of 1886. In United States museums, the move towards displaying natural history specimens in their natural contexts in "habitat groups" began in about 1879 following earlier precedents in Britain (Kohlstedt 1980). Whether influenced by developments in Britain or America, the trend continued at Auckland Museum with the large shag display of 1912, and others that followed soon after. The zenith in natural history diorama-building at Auckland was reached with the large dome-backed dioramas central to the 1972 Bird Hall, which delighted the public for 24 years.

Since the closure of this gallery in 1996 a new chapter has unfolded. All of Auckland Museum's natural history galleries have been redeveloped with a themed approach stressing time sequences and habitats. As in the past, land vertebrates specimens continue to be of central importance to many of the new exhibits.

Acknowledgements. I thank Graham (E.G.) Turbott for helpful discussion of the museum's history; Stuart Park for sharing his research on I. St John; and Sandy Bartle, Ross Galbreath, Nigel Prickett and Richard Wolfe for useful comments on a draft of this paper.

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APPENDIX 1. Major or interesting accessions of groups of land vertebrates specimens, Auckland Museum, 1876-1995, arranged alphabetically by source. Most were acquired by purchase, exchange or donation. Some notable collections by staff members during their employment are included. Compiled largely from accessions lists in the museum's annual reports.

ADAMS, C.F. (of Illinois, U.S.A.): "Skins of Orang-Utan, Proboscis Monkey, Lemur, Sun Bear, Pigmy Deer, Argus Pheasant, and other Bornean Animals", purchased (Ann. Rep. 1888-89). "Collection of Bornean animals, including stuffed specimens of the following species: Orang-Utan ... [11 others]", purchased (Ann. Rep. 1890-91). "Collection of North American Batrachians [6 species]", exchanged (Ann. Rep. 1890-91).

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK: Study-skins of Western Samoan birds from the Whitney South Sea Expedition, 1924. A condition of the collecting permit for Western Samoa issued by the New Zealand Government (the colonial power) was that a named specimen of all birds collected be submitted; 47 specimens came to Auckland Museum. Also, specimens of three species of petrels from Bounty Islands received 1926-27 (Ann. Rep.).

ARCHEY, G. (of the museum staff): Moa bones (collected with assistance from Sir Frank Mappin, A.T. Pycroft and Sir Carrick Robertson) from limestone caves in the Waikaremoana and King Country areas and from sand-dunes at Doubtless Bay, 1930-40.

AUCKLAND ZOO: Birds, mammals and reptiles from Auckland Zoological Park, and before that "Onehunga Zoo", 1912-1960.

AUSTRALIAN MUSEUM, SYDNEY: "103 Australian Bird Skins", exchanged (Ann. Rep. 1878-79).

B.A.N.Z.A.R. EXPEDITION: Bird skins, spirit specimens and eggs from Antarctica obtained by the British, Australian, New Zealand Antarctic Research Expedition collected by R.A. Falla (of the museum staff), 1929-31.

BELL, R.: Bird specimens collected by Roy Bell on the Kermadec Islands. "103 Bird-skins" including "petrels and other oceanic birds", purchased (Ann. Rep. 1911-12).

BELL, T.: Bird specimens collected by T. Bell on the Kermadec Islands. "Skins of *Phaethon* and *Procellaria* sp., Collection of Birds' Eggs" (Ann. Rep. 1888-89). "Petrels and Land Rail" (Ann. Rep. 1889-90). "18 Bird Skins" (Ann. Rep. 1890-91).

BROWN, Rev G.: Bird mounts from New Britain, New Ireland, Rotuma and Samoa. "100 bird skins from New Britain and New Ireland: Purchased by special subscription", also "12 Marsupials, bats, &c. ... reptiles, &c.; eggs of the cassowary, megapode, &c." (Ann. Rep. 1876-77). "10 Bird Skins from the Solomon Islands" (Ann. Rep. 1882-83). George Brown was a missionary, and many of his specimens of Melanesian mammals and birds went to the British Museum (Various Authors 1906).

BRYANT, D.S. (of San Francisco): "25 Californian Bird Skins", exchanged (Ann. Rep. 1877-78).

BUDDLE, G.A. (of the museum staff): Collection of 800 eggs and 1,200 photographic negatives of New Zealand birds presented 1931-32, or received posthumously in 1951.

CANTERBURY MUSEUM, CHRISTCHURCH: "Specimen of the White Crane" (Ann. Rep. 1873-74). New Zealand bird skins, casts of *Harpagornis* bones, a skeleton of *Rhea americana*, exchanged (Ann. Rep. 1876-77). "Skeleton of African Ostrich, specimens from the Bone Caves of Central Europe", exchanged (Ann. Rep. 1878-79). "Skeleton of Giraffe" (Ann. Rep. 1879-80). "96 Bird Skins, 10 Skeletons",

exchanged (Ann. Rep. 1881-82). "Bones of Cave Bear", exchanged (Ann. Rep. 1890-91). "Skin of Laughing Owl", exchanged (Ann. Rep. 1891-92). "Moa Skeleton; Moa Feathers", exchanged (Ann. Rep. 1892-93). "Specimen of *Phalacrocorax Ranfurlyi*", exchanged (Ann. Rep. 1903-04).

CHOLMONDELY, Hon. R. (of London): "21 Skins of Trogons and other birds", exchanged (Ann. Rep. 1882-83).

COLONIAL MUSEUM, WELLINGTON (now Museum of New Zealand): Numerous specimens received from "The Director of the Colonial Museum", including the following more notable ones. "Skeleton of Apteryx Australis" (Ann. Rep. 1870-71). "20 Casts N.Z. [Mesozoic marine] Reptilian Remains", model eggs of moa and kiwi, "2 Skins Xenicus Stokesii", egg or eggs of *Coturnix novaezelandiae* (Ann. Rep. 1871-72).

COMBES, F.H.: "25 New Zealand Birdskins" (Ann. Rep. 1880-81). Young kangaroos and opossums in spirits (Ann. Rep. 1881-82). "New Zealand Bird Skins; Skin of White Swan" (Ann. Rep. 1882-83). "New Zealand Bird-skins" (Ann. Rep. 1883-84). "Skins of Kangaroo, Opossum, and Wallaby; 13 New Zealand Bird Skins" (Ann. Rep. 1890-91). "12 New Zealand Bird-skins" (Ann. Rep. 1892-93). "3 Young of Harrier Hawk" (Ann. Rep. 1927-28). "Extensive collection of N.Z. and foreign Birds, mounted and Cabinet-skins" (Ann. Rep. 1930-31).

CRABTREE, T. (of Napier): Exposed and partly exposed fossils of Late Cretaceous marine reptiles from Mangahouanga, purchased 1989.

DANNEFAERD, S.: Bird skins from the Chatham Islands, including those of *Bowdleria rufescens*, purchased: 10 (Ann. Rep. 1911-12), 19 (Ann. Rep. 1915-16), number not stated (Ann. Rep. 1918-19).

FINSCH, Dr O. (of Germany): "24 Skins of Humming Birds", presented (Ann. Rep. 1881-82).

FLORENCE MUSEUM (Imperial Museum of Natural History), ITALY: "392 Skins of Birds and Mammals", "European and exotic", exchanged (Ann. Rep. 1881-82). "160 Bird-skins, 25 Mammals", plus 30 "alcoholic specimens of reptiles", exchanged (Ann. Rep. 1888-89). "Thirteen Mammals, set up; fifteen Bird Skins", exchanged (Ann. Rep. 1891-92).

GARNIER, Dr (of Lucknow, Ontario, Canada): "150 Bird Skins, 8 Mammals, 28 Reptiles" from North America, exchanged (Ann. Rep. 1881-82). "140 Skins of Mammals, Birds and Reptiles", exchanged (Ann. Rep. 1882-83).

GENEVA MUSEUM (Muséum d'Histoire Naturelle), SWITZERLAND: "60 European Bird Skins, collection of European Birds' Eggs", exchanged (Ann Rep. 1878-79). "12 Mammals, 52 Birdskins", exchanged (Ann. Rep. 1880-81).

GILLIES, T.B. (of Auckland) and eight others: "100 Queensland Bird Skins" procured by "special subscription" (Ann. Rep. 1871-72).

GOLDIE, A.: Ten marsupials and 110 bird skins from New Guinea, purchased (Ann. Rep. 1879-80). Andrew Goldie was a Scottish naturalist who was based at Port Moresby c. 1880, where he owned the store. He discovered gold near the settlement in 1878 (Souter 1963: 44-5).

HUGHES, A.R.: Bird study-skins from Sri Lanka, presented. "Collection of Bird Skins from India and Ceylon" (Ann. Rep. 1930-31). "85 birdskins" (Ann. Rep. 1931-32). A.R. Hughes was honorary New Zealand Government Agent in Colombo.

HUNT, G.: 130 New Caledonian lizards, presented 1994-95.

KEMP, R. (of Long Sutton, England): "Series of Skins of Small English Mammals" (Ann. Rep. 1909-10).

KINLOCH, D.I.: 100 wallaby skulls collected on Kawau Island, 1968-72, presented by Auckland University 1992.

McGREGOR, W.R.: 334 study-skins of birds and marsupials, mostly collected in Australia in the 1930s, presented by Auckland University 1992. McGregor (1894-1977) was head of the Zoology Department at Auckland University where he built up a teaching museum.

McLEAN, J.C.: Eggs of New Zealand birds (154 sets) collected by J.C. McLean during the period 1880-1914, presented by B.L. Chambers 1933-34.

MUNRO, G.C.: New Zealand bird eggs (Ann. Rep. 1888-89). "Egg of Hawk" (Ann. Rep. 1889-90). New Zealand bird skins, nests and eggs (Ann. Rep. 1890-91). "Thirteen bird-skins from the Sandwich Islands [Hawaii]" (Ann. Rep. 1911-12). Birds from New Zealand and Hawaii collected by G.C. & H.S. Munro 1880s and 1890s, presented by A.C. Munro 1954. G.C. Munro was honorary Associate in Ornithology at the Bishop Museum, Hawaii (Munro 1944).

OTAGO MUSEUM, DUNEDIN: Foreign bird skins (100), mammals (7), moa bones, exchanged (Ann. Rep. 1876-77).

PARIS MUSEUM (Muséum National d'Histoire Naturelle), FRANCE: "Extensive series of Mammals, Bird Skins, &c.", exchanged (Ann. Rep. 1877-78).

PARSONS, Mr. J. (of Vava'u, Tonga): "61 Bird Skins, 10 Bats ... various Reptiles", presented (Ann. Rep. 1878-79).

PYCROFT, A.T.: Birds, reptiles and amphibians from the Solomon Islands collected by A.T. Pycroft 1932, presented (Ann. Rep. 1932-33: 43).

RINKE, D.R. (of Germany): 32 study-skins of Tongan birds, presented 1993-94.

ROYAL COLLEGE OF SURGEONS, LONDON: Articulated skeletons of smaller mammals, birds, and other vertebrates, exchanged (Ann. Rep. 1879-80). "Skull of Tiger, Polar Bear, and Camel", exchanged (Ann. Rep. 1883-84).

SMITHSONIAN INSTITUTION, WASHINGTON, D.C.: Either "300" or "over 400" skins of North American birds, exchanged (Ann. Rep. 1886-87). Skeleton of bison, skulls of fur seal and eared seal, exchanged (Ann. Rep. 1890-91). 16 skins of mammals, 10 bird skins, 14 reptiles, exchanged (Ann. Rep. 1891-92).

SMYTH, W. (of Dunedin): New Zealand bird skins, purchased 1885-86, 1886-87 and 1887-88 (Ann. Reps.).

STEAD, E.F. (of Christchurch): Skins, nests and eggs of New Zealand birds, presented (Ann. Rep. 1933-34: 14).

WARD, Prof. H.A. (of Rochester, U.S.A.): Plaster casts of fossils, exchanged, received 1881. "Human Skeleton, set up", exchanged (Ann. Rep. 1883-84). "Mounted Skeleton of African Ostrich", exchanged (Ann. Rep. 1897-98).

MONITORING STUDIES OF THE BENTHIC ECOLOGY OF WAITEMATA HARBOUR, NEW ZEALAND

BRUCE W. HAYWARD, MARGARET S. MORLEY, JESSICA J. HAYWARD, A. BRETT STEPHENSON, WILMA M. BLOM, KATHRYN A. HAYWARD AND HUGH R. GRENFELL

Abstract. Changes in a benthic community off Cheltenham Beach were monitored following the rapid die-off of a dense, subtidal (5 m depth) bed of the introduced Asian date mussels (*Musculista senhousia*). Die-off was followed by a 6-9 month flush of bivalves and polychaetes, which thrived on the nutrient-rich muddy substrate that had built up around the mussels. These high abundances of opportunistic suspension- and deposit-feeders were replaced by a short flush of the predatory and scavenging mud crab (*Macrophthalmus hirtipes*). Benthos diversity and density progressively declined over a 2-3 year period as the muddy substrate disappeared and the pre-existing sand beneath was exhumed. The muddy substrate of the mussel bed supported a fauna substantially different and richer than that in the background sandy substrate (twice the diversity, five times the density, abundant worms).

Three and a half years of monitoring an initially dense bed of native horse mussels (*Atrina zelandica*) at 14 m depth in Rangitoto Channel indicated rapid growth during their first 3-4 years (35 mm/month length increase). This was followed by the virtually complete loss of the bed over a 2-3 year period (from a density of 200-300/m^2 to 1-35/m^2), possibly a result of storm scour, shell damage and subsequent predation, or carrying capacity being exceeded as individuals grew.

Two and a half years of monitoring recently re-established intertidal seagrass circles (*Zostera novozelandica*) at Cox's Creek showed mean monthly radial growth rates of 150 mm/month with no significant seasonal variation. If this is the start of the return of flourishing seagrass beds to the Waitemata Harbour shores (lost through a fungal outbreak 50-60 years ago), then it will take several more decades to develop extensive beds.

Monthly monitoring of populations of the introduced small semelid bivalve *Theora lubrica* in a low tidal muddy habitat in Hobson Bay revealed considerable variation in density (30-850/m^2). During 24 months of monitoring, six cohorts were identified based on the seasonal change in the size composition. These showed slower growth rates and longer-lived populations in cooler months (0.5 mm/month, 6-8 months longevity) than in the summer (2-3 mm/month, 2-3 months longevity). Significant die-offs occurred in spring in both years, but the very low densities of summer 1997-98 were not matched in the summer of 1998-99 when the highest densities were recorded.

Cores showed that the majority of *Theora lubrica* live 10-30 mm below the surface of the substrate. Studies of size distribution of populations at different tidal heights provided no evidence of any migration up or down the shore as they mature. Controlled feeding trials showed that the mud crab *Macrophthalmus hirtipes* is a major predator of *Theora lubrica*, with one crab capable of consuming up to seven of these small bivalves/

day. Monitoring revealed an apparent correlation between high crab numbers and low *Theora* densities and suggested that crab predation could control *Theora* density.

KEYWORDS: New Zealand, Auckland, Waitemata Harbour, monitoring, ecologic change, *Musculista senhousia, Atrina zelandica, Zostera novozelandica, Theora lubrica*, introduced marine species.

INTRODUCTION

Of New Zealand's many splendid harbours, the Waitemata Harbour (Fig. 1) in Auckland (Lat 36° 50' S Long 174° 45'E), is the most utilised and impacted by human activities. It is the busiest port in the country, has the most intensely industrialised and densely populated catchment (c. 750 000), and is the playground for the country's largest city. It is also home to the largest number of introduced exotic marine organisms in New Zealand (66 species, Hayward *et al.* 1999). It is imperative that we better understand the ecology of the harbour and the impacts of introduced species, so that we can monitor the harbour's health in the face of pollution, increased sediment and freshwater runoff, and the threat of additional marine introductions.

The small monitoring studies documented here have evolved out of the results of larger scale subtidal and intertidal surveys (Hayward *et al.* 1997, 1999) undertaken when most of the authors were either employed by, or volunteers at, the Auckland War Memorial Museum.

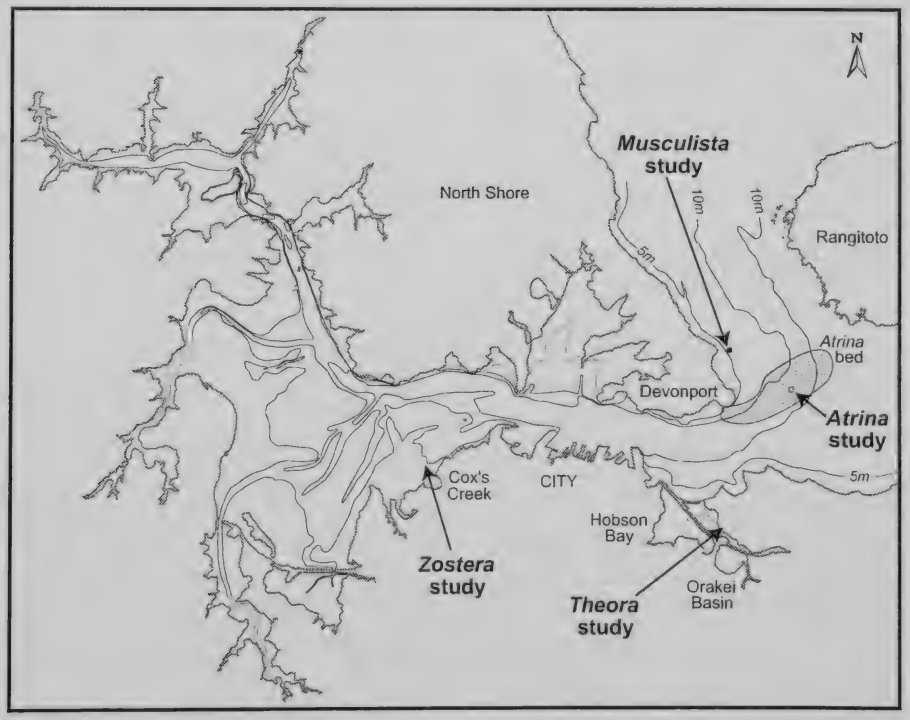

Fig. 1. Location in the Waitemata Harbour of monitoring sites for our studies of: an Asian date mussel (*Musculista senhousia*) off Cheltenham; a horse mussel bed (*Atrina zelandica*) in the Rangitoto Channel; seagrass (*Zostera novozelandica*) at Cox's Creek; and the small semelid bivalve (*Theora lubrica*) in Hobson Bay.

PART 1—RECOVERY OF A SUBTIDAL ECOSYSTEM FOLLOWING DIE-OFF OF AN ASIAN MUSSEL INFESTATION

(by BWH, ABS, MSM, HRG, WMB)

INTRODUCTION

The small Asian mussel, *Musculista senhousia*, was first discovered in New Zealand in the Waitemata Harbour about 1978 (J.E. Morton pers. comm., Willan 1985). Within a decade it spread as far north as Parengarenga and south to East Cape, but does not appear to have extended its range since then (Willan 1985, 1987; Morley 1988). It lives in patches (5 m^2-10 ha) that accumulate thick mud drifts over the shallow subtidal and low tidal seafloor in many parts of the Waitemata Harbour (Hayward *et al.* 1997, 1999; Hayward & Hayward in press). These beds are continually dying off, with new patches being established each year (Creese *et al.* 1997).

During a reconnaissance survey of the subtidal, soft bottom benthos of the Waitemata Harbour in July 1993, one dredge station taken in 5 m of water off the north-west end of Cheltenham Beach, Devonport (Fig. 1), encountered a muddy thicket of live mature *Musculista senhousia*. Its existence as an extensive bed was confirmed by diving observations (S. Hooker pers. comm. 1993) and a further dredge haul taken in November 1993. The station was resampled by dredging in February 1994, and subsequently monitored with further sampling in June and September 1994 (one sample each) and in August 1995, January and September 1996, and February 1997 (with four replicate dredge samples). The February 1994 sample encountered only dead shells of *Musculista senhousia*, suggesting a die-off of the bed, which was confirmed by subsequent sampling (although two live specimens were recorded in June 1994) and by a further diving inspection (S. Hooker pers. comm. 1995).

A serendipitous result of these dredge surveys and monitoring has been the documentation of the recovery of an area of seafloor and its biota, following its colonisation for approximately two years by a dense mat of introduced Asian date mussels and the resulting accumulation of a thick drift of mud. In New Zealand the impact of Asian mussel beds on the native ecosystem has previously been documented in intertidal situations in the Tamaki Estuary (Creese *et al.* 1997).

METHODS

The subtidal station was relocated each time with an accuracy of ± 20 m using satellite GPS and local landmarks. Samples were hand-hauled from a 4 m dinghy powered by a small outboard motor using a naturalist's dredge with 10 litre capacity. The dredge sampled 60-100 mm into the seafloor sediment and generally came up 90-110% full, having sampled 0.15 m^2 of seafloor sediment. In most instances the dredge bit deeply into the relatively soft substrate and needed to be dragged only a few metres across the sea floor before being filled. Each sample was washed over a 1 mm sieve to remove mud and sand, and the residue was fixed with preservative. In the laboratory all preserved live organisms were hand picked, identified, and counted.

The results were tabulated (Appendix 1) and the occurrence through time of the more common taxa graphed to illustrate the faunal change after the die-off of the *Musculista* (Figs 2, 3).

RESULTS

Dredge samples of the thicket in July and November 1993 had scaled densities of live Asian mussels of 150-200/m^2 of sea floor. These densities are relatively low compared with those

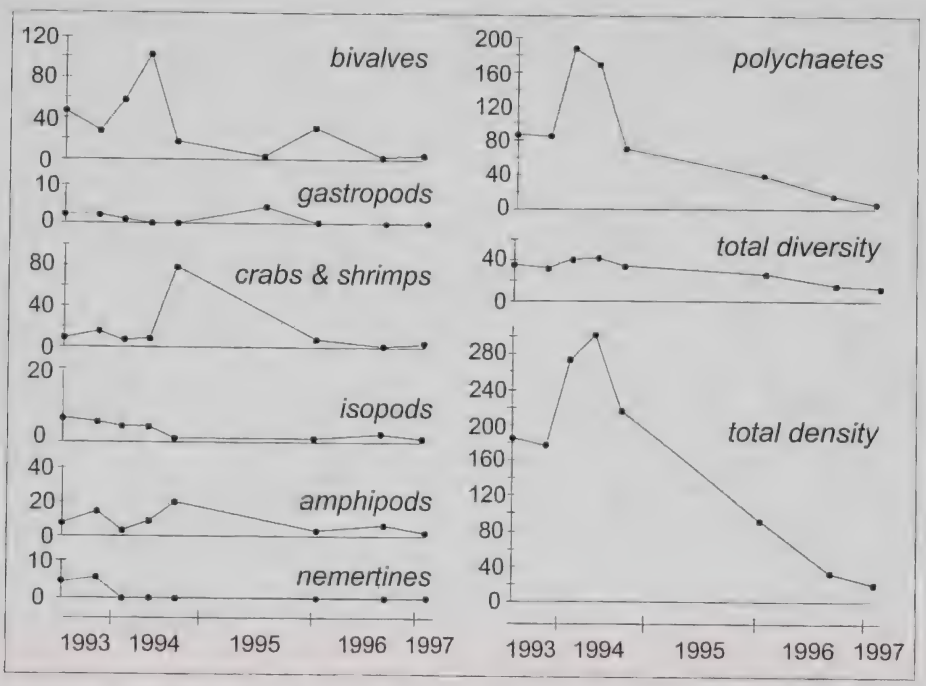

Fig. 2. Graphs showing changes in abundances of seven faunal groups, overall diversity (number of species) and overall density (total number of individuals) following the die-off of an Asian mussel thicket in the subtidal monitoring station off the west end of Cheltenham Beach, from July 1993 to February 1997.

recorded in some intertidal situations around the Waitemata (Creese *et al.* 1997, Hayward & Hayward in press). The last record of living mussels (10/m^2) was in June 1994. The mussels in the thicket mostly died off during the summer of 1993-94 and the thicket broke up and washed away in the months that followed. The dredged sediment noticeably changed from dominantly mud in 1993 to cleaner sand several years later.

A simple diversity curve (number of species present) indicates 32-36 species/0.15 m^2 were living in the thicket (Fig. 2); it increased slightly to 41-43 species during the nine months following die-off; then progressively decreased to less than half that diversity (13-15 species), 30-36 months following die-off. A very similar pattern is seen in the density curve (number of individuals). The thicket supported c. 1200 individuals/m^2, which increased to 1800-2000 in the 3-6 months after die-off, and then progressively decreased to 150-250, 30-36 months after die-off. The major contributors to these diversity and density curves are the polychaete worms and to a lesser extent the infaunal bivalves, which show parallel results (Fig. 2).

Nemertine worms and isopods were both more numerous in the thicket than following its die-off. Gastropod and amphipod numbers show only minor variations throughout the monitoring period. Decapod crustacea (crabs and shrimps) have slightly higher densities in the thicket than in the sand 36 months later, with an unusual peak density nine months after die-off (Fig. 2), produced by a flush (500/m^2) of the mud crab, *Macrophthalmus hirtipes* (Fig. 3).

Species abundance curves (Fig. 3) show that many species (e.g. polychaetes—*Axiothella quadrimaculata, Glycera lamellipoda, Paprionospio, Prionospio, Terebellanice*, Capitellidae; the amphipod *Torridoharpina hurleyi*; the isopod *Natalolana albicaudata*; the holothurian *Trochodota*

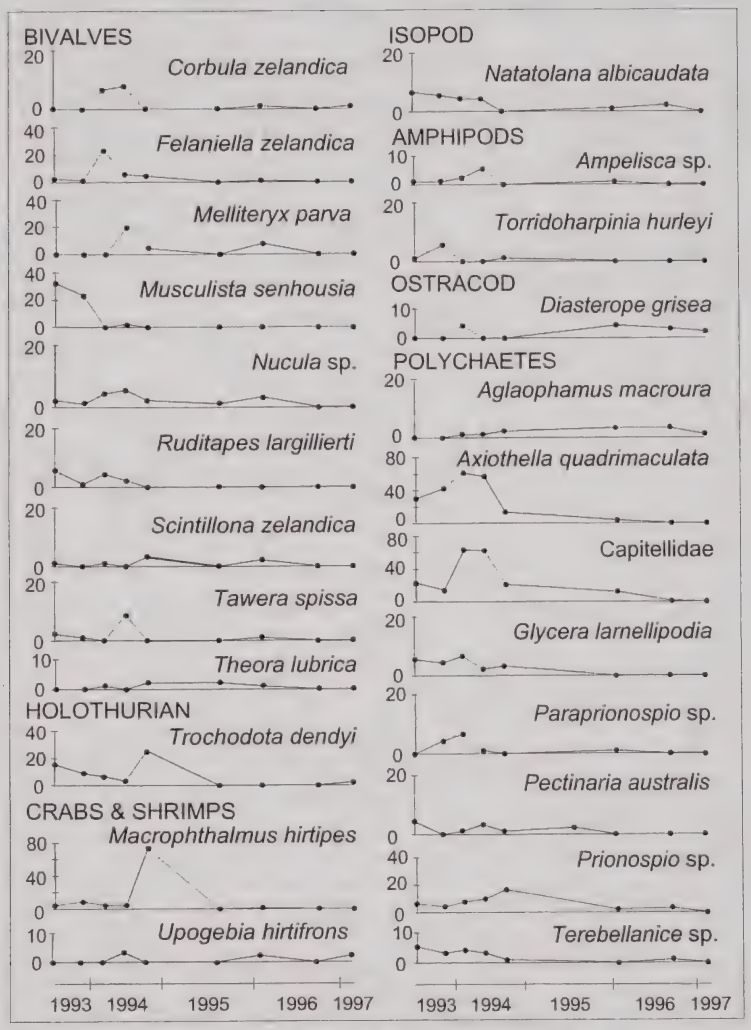

Fig. 3. Graphs showing species abundance changes following the die-off of an Asian mussel thicket in the subtidal monitoring station off the west end of Cheltenham Beach, from July 1993 to February 1997.

dendyi) had considerably greater abundances in the muddy thicket than in the sand substrate, 30-36 months after die-off.

Species that were not recorded living in the thicket and with significant, but patchy, abundances thereafter, include the bivalves *Corbula zelandica, Felaniella zelandica, Melliteryx parva, Theora lubrica*; the shrimp *Upogebia hirtifrons*; ostracod *Diasterope grisea*; and polychaete *Aglaophamus macroura*.

Many species had a peak abundance in the 3-6 months following die-off, including the bivalves *Corbula zelandica, Felaniella zelandica,* and *Tawera spissa*; the amphipod *Ampelisca* sp.; and the polychaetes *Axiothella quadrimaculata, Paraprionospio* sp., and Capitellidae. Several species (e.g. the holothurian *Trochodota dendyi*; the polychaete *Prionospio*; and the crab *Macrophthalmus hirtipes*) had their peak abundance nine months after die-off.

DISCUSSION

Studies of intertidal Asian date mussel thickets show them to have a non-uniform patchy distribution; they live for about two years and many die off during the higher temperatures of mid summer. As the thicket ages and dies it progressively erodes away (Creese *et al.* 1997). The subtidal thicket off Cheltenham exhibited a similar pattern, although we can only infer the mussels were about two years old when they died.

Our monitoring of the recovery of a subtidal site following the die-off of an invasive mussel bed also documents the impact of the mussel bed on the original ecosystem, assuming that the site had fully recovered to its original state after 30-36 months. The byssal threads of the Asian date mussels accumulate mud, which builds to a depth of 50-150 mm and grossly modifies the character of the substrate. This appears to have an adverse impact on some of the infaunal, suspension-feeding bivalves (e.g. *Corbula zelandica, Felaniella zelandica, Melliteryx parva*) and possibly the large carnivorous polychaete *Aglaophamus macroura*, but resulted in an increase in the diversity and density of the fauna overall, as mud-loving organisms colonised and flourished (e.g. the holothurian *Trochodota dendyi,* many polychaetes, the isopod *Natatolana albicaudata*, and the amphipod *Torridoharpinia hurleyi*).

The sessile, filter-feeding Asian date mussels gather and spill numerous food particles, which accumulate around them, together with excreted material, as high-nutrient mud. The die-off of mussels was closely followed over the next 6-9 months by a flush of suspension—and deposit-feeding juvenile infaunal bivalves (*Corbula, Felaniella, Melliteryx, Tawera, Nucula*), large amphipods (*Ampelisca*) and polychaetes (*Axiothella, Paraprionospio, Prionospio*), which rapidly colonised the newly available nutrient-rich substrate. This flush of opportunistic animal life coupled with warmer spring temperatures, probably resulted in a flush of the predatory and scavenging mud crab (*Macrophthalmus hirtipes*) recorded nine months after mussel die-off. The mud crab peak was accompanied by a corresponding decrease in the abundance of many of the opportunistic prey species.

Diversity and density of most organisms progressively fell to a relatively low, stable level 30-36 months after the mussel die-off, as the relatively clean sand substrate was re-established.

PART 2—DYNAMICS OF A SUBTIDAL HORSE MUSSEL BED

(by BWH, ABS, MSM, HRG)

INTRODUCTION

When Powell (1937) surveyed the subtidal benthos of Waitemata Harbour in the 1930s, he recorded no live horse mussels (*Atrina zelandica*). It was therefore surprising that our reconnaissance dredge survey of the same area in July 1993 showed an extensive horse mussel bed in muddy fine sand covering a triangular area between south Rangitoto, Bean Rock, and Devonport (Fig. 1; Hayward *et al.* 1997). The bed was most dense and extensive on the outside of the bend of the main harbour channel, and one station here in 14 m of water (Fig. 1) was chosen to monitor the growth rate and life span of the mussels. The station was resampled by dredging in November 1993, February, June and September 1994 (one sample each) and in August 1995, January and September 1996, and February 1997 (with four replicate dredge samples).

This horse mussel "invasion" of the Waitemata Harbour was a natural, rather than a human-assisted phenomenon. Horse mussel beds are transitory (Grant-Mackie 1987) and the Waitemata Harbour bed was no exception. The density of live specimens decreased progressively with very

few live mussels left by mid 1996. In 1995 and 1996 huge volumes of horse mussel shells were washed up on nearby beaches during storms.

METHODS

Field methods of station location, dredging, sieving and preservation were the same as in the study on Asian date mussels. In the laboratory, the live horse mussels were sorted into 10 mm size classes, based on the length of their shells, and counted. Because of the relatively shallow depth of penetration of the dredge, many of the larger horse mussels had their beak ends cut off and their total lengths were estimated using the tapering shape of their shells.

RESULTS

The mean length of the horse mussels increased from 118 mm in July 1993 to 166 mm in September 1994 giving a mean annual growth rate of 41 mm/yr (3.5 mm/month). The mean size then remained static for the next 18 months and probably 2.5 years, although numbers dredged after January 1996 were insufficient for an accurate assessment (Fig. 4).

The density of horse mussels in the study site progressively decreased over time from 150-200/m^2 in July and November 1993 to 80-100/m^2 a year later, to 40/m^2 another year later and to 2-5/m^2 by August 1996 and February 1997 (Fig. 4).

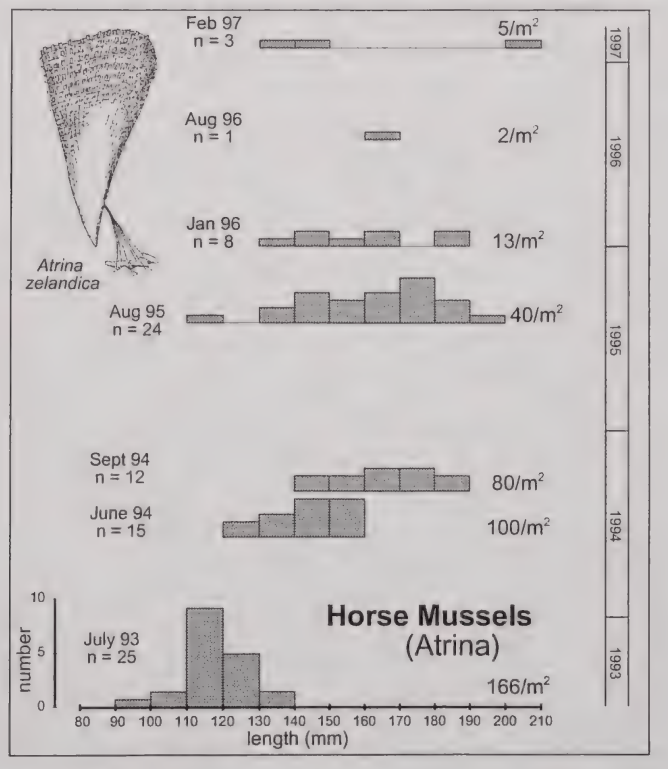

Fig. 4. Histograms showing size distribution of horse mussels during each sampling of the bed north of Bean Rock, from July 1993 to February 1997. The number of specimens measured (n) and density (n/m^2) are also given.

DISCUSSION

As sample sizes are relatively small, conclusions from our results are tentative. If the horse mussels grew in their early years at the same rate they did during the study, then the population was three years old when monitoring began in July 1993. This population appears to have started dying off at 3.5 years in age and this continued for the next 2.5 years with resulting progressive decrease in density. After six years there were very few horse mussels alive. The large drifts of horse mussel shells washed up along Auckland's East Coast Bays in 1995 and 1996 were undoubtedly derived from the die off of this large bed and possibly other beds further north that had settled 4-5 years earlier.

We can only speculate as to the cause of the die off. Grant-Mackie (1987) attributed a similar die off in beds north of the present study area to storms eroding the subtidal substrate. Many horse mussels were "washed-out" and others suffered shell damage which allowed predators such as whelks to attack the soft parts (Grant-Mackie 1987). Horse mussels are the principle host to the pea-crab *Pinnotheres atrinocola* and specimens were recovered from horse mussels in this study. At no stage, however, did we record high incidences of crab infestations, such as those noted in McLay (1988), and so we do not infer pea-crab parasitism as contributing to the dynamics of our horse mussel study population.

Our monitoring results suggest that the horse mussels grew rapidly for the first four years of their lives, after which growth virtually stopped or certainly slowed dramatically. We know of no other published growth rates for *Atrina zelandica*, although Cameron Hay undertook detailed measurements on tagged individuals in the Marlborough Sounds for 4.5 years in the 1980s. He recorded rapid growth in their first two years with large shells at least five years and possibly up to 15 years old (C. Hay pers. comm.).

PART 3—RETURN OF INTERTIDAL SEAGRASS PATCHES

(by BWH, KAH, JJH, MSM)

INTRODUCTION

The tidal flats around the fringes of the central Waitemata Harbour were formerly covered in green seagrass, *Zostera novozelandica*, a marine angiosperm, but it was virtually wiped out in the Auckland region by a fungal outbreak 50-60 years ago (Armiger 1964, Dromgoole & Foster 1983). *Zostera* roots help stabilise the substrate and the plant is reputed to improve water quality in polluted habitats.

The only area in the harbour with substantial seagrass beds in the 1990s was the southern shore between Meola Reef and the harbour bridge. Here, at and below MLWS, large areas of soft sand are clothed in seagrass. During intertidal shoreline surveys in the mid and late 1990s, we noted that small circles of seagrass seemed to be reappearing on the tidal sand flats in several places around the Waitemata Harbour (e.g. Orakei Basin, Okahu Bay, St Heliers, Karaka Bay). One of the greatest concentrations of small seagrass circles was found between mid and low tide at the mouth of Cox's Creek, Herne Bay (Fig. 1). This site was selected to monitor the circles to investigate whether they provided any evidence of the return of the former seagrass cover and to document their seasonal and annual growth rates.

At Cox's Creek we observed that fine sand and silt builds up around the binding roots of the seagrass so that the substrate is often softer than the surrounding area. Dead cockle shells are caught by the seagrass, accumulating into thick drifts which in places bury and kill off parts of the circles. New circles form by vegetative propagation—a broken runner from an existing

patch is swept to a new site by the tide and sends down roots thus establishing the nucleus of a new patch. New branching runners grow radially outwards forming a circular patch.

METHODS

A pace and compass plan of the seagrass circles near the mouth of Cox's Creek was prepared on 7 March 1996 (Fig. 5). Each circle was assigned an identification letter which was used throughout the monitoring. During each monitoring visit, two diameters of each circle were measured with a tape measure, one parallel to the sea shore and the other perpendicular to it. The circles were remeasured in August and October 1996, January, March, August and October 1997, and April and October 1998. New small circles that became established within the study area during the monitoring were progressively added. The plan of the seagrass circles was redrawn at the conclusion of monitoring in October 1998 (Fig. 5). Results of the monitoring of each circle diameter were graphed as radial growth rates (Fig. 6). Mean monthly radial growth rates for all circle diameters have been calculated for each of the intervals between measurements.

RESULTS

During the monitoring period all circles increased in size by outwards radial growth. There was no significant difference in growth rates in any direction—an observation supported by the circular to near-circular shape of all patches. Several of the circles increased in size and coalesced with adjacent ones (Fig. 5). During the 31 months, total area of the intertidal *Zostera* circles increased by 150% (from 2400 m^2 to 6000 m^2).

The mean monthly radial growth rate for all *Zostera* circles for the 31 months of monitoring

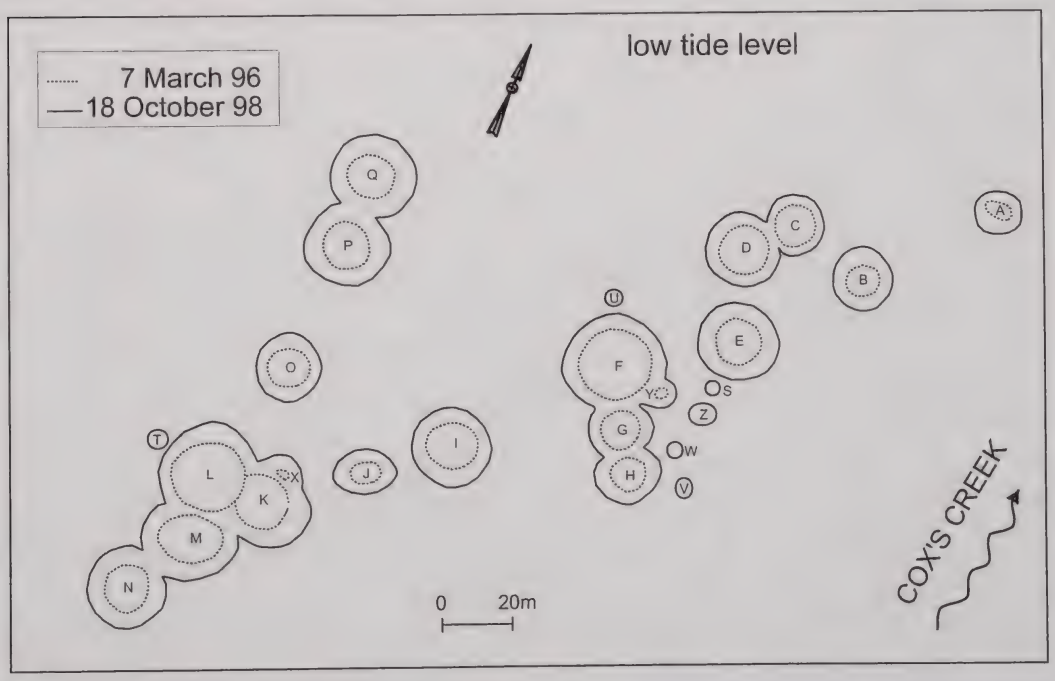

Fig. 5. Plan of seagrass circles (A-Q, S-Z) between mid and low tide levels at Cox's Creek at the start and finish of the growth monitoring programme from March 1996 to October 1998.

was 150 mm/month. The period of most rapid growth (mean 210 mm/month) was early spring 1996 (Aug.-Oct.) and slowest growth (mean 90 mm/month) was late summer 1997 (Jan.-Mar.). In early spring 1997 (Aug.-Oct.), the mean growth rate was 120 mm/month and over summer (Oct. 1997-Apr. 1998) it was 130 mm/month.

The plot of increasing diameters of individual *Zostera* circles (Fig. 6) indicates that while there is considerable variability, the overall growth rate over the full 31 months is remarkably consistent. There does not appear to be any consistent seasonal or other pattern. Growth rate projections suggest that the largest circle in 1998 (F—30 m diameter, Fig. 5) was nine years old.

DISCUSSION

Studies on the growth of *Zostera* in Australia have shown marked seasonal variability with maximum biomass in summer and minimum in winter, with biomass differences between the two seasons ranging between two and 40 times (e.g. Kerr & Strother 1990, McKenzie 1994). Similar major seasonal changes in the apparent health and cover of *Zostera* have been noted in Manukau and Parengarenga Harbours in New Zealand (pers. obs. M. Morley, F. Thompson respectively). It appears that once established, seagrass beds display these seasonal patterns of abundance and growth. Our monitoring did not investigate seasonal biomass variability and focussed on the growth rates of the runners and shoots as measured by radial increase in size of the circles. It is still surprising however that we did not find any significant seasonality in their growth rates.

Long-time local residents of Cox's Creek recall that in the 1940s and 1950s most of the

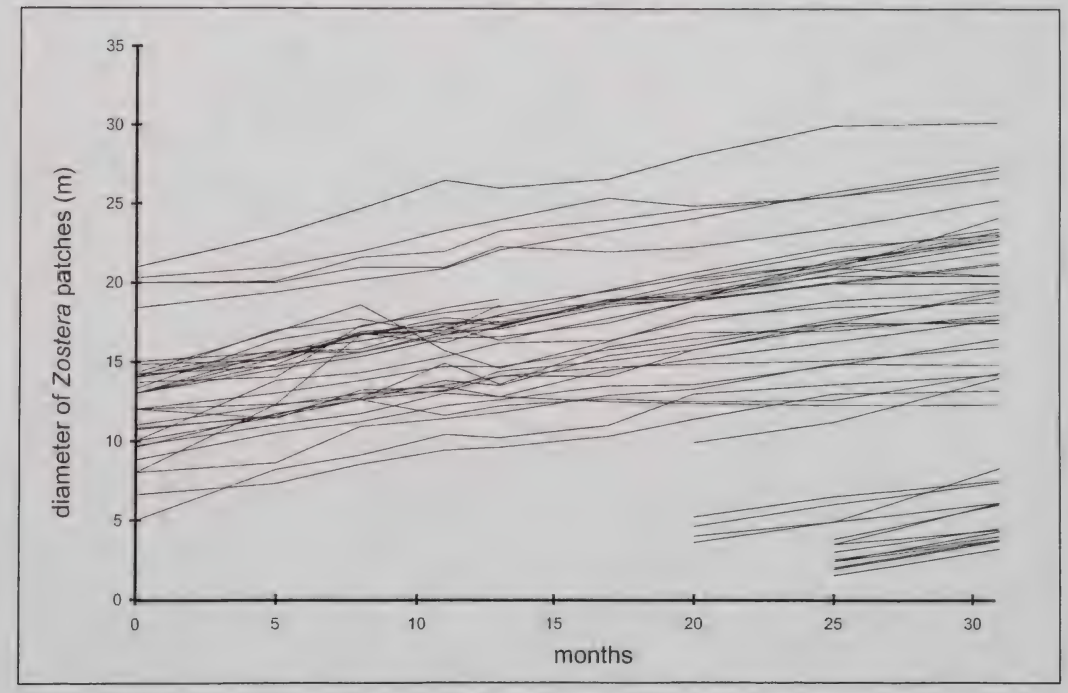

Fig. 6. Graph showing the trend of increasing diameters of seagrass circles (two diameters at right angles measured/circle) during the monitoring programme. Diameter measurements on new seagrass circles that became established during the monitoring appear at bottom right.

intertidal flats were covered in thick seagrass. One anonymous local resident believes that the extensive seagrass of the past dated from a time of extensive sewerage pollution of the bay, before establishment of the Mangere Sewerage Plant. He has also noted the return of seagrass in recent years and correlates it with periodic sewerage overflows into Cox's Creek. He says he has noted some sewerage washing up around the Cox's Creek coast at high tide level; the recent establishment of flourishing seagrass patches at this unusually high tide level (not part of this study) may be correlated with the sewerage nutrients. It is far less certain that sewerage overflows into Cox's Creek have anything to do with the return of the *Zostera* circles at lower tide levels. Low-tide *Zostera* have been noted returning in several places around the harbour and many are not at sites of known sewerage overflows.

Of all the harbours in northern New Zealand, the one with the most extensive intertidal seagrass beds is Parengarenga. Here the intertidal substrate is mostly clean quartz sands and its catchment is a mix of scrublands and low intensity pastoral farmland. Parengarenga probably has the lowest levels of anthropogenic nutrient input of any of the northern harbours and appears to be a direct contradiction to the supposed link between seagrass vitality and high nutrients.

If major seagrass beds are indeed returning to the Waitemata Harbour, the growth rates we have documented suggest that it could take several more decades to achieve.

PART 4—POPULATION DYNAMICS OF A SMALL INTRODUCED SEMELID BIVALVE

(by MSM, BWH)

INTRODUCTION

The small, thin-shelled Asian semelid bivalve *Theora lubrica* (maximum length 15 mm), arrived in the northern harbours of New Zealand about 1972, probably in ship ballast water from its home in Japan (Climo 1976, Dromgoole & Foster 1983). It has since spread to most other ports in the country (Hayward 1997). In recent decades, *Theora lubrica* has become the dominant mollusc in mud and muddy sand in the extensive low tidal and shallow subtidal flats throughout most of the Waitemata Harbour (Hayward *et al.* 1997). It seems that *Theora lubrica* can rapidly colonise disturbed and muddy habitats and is perhaps the most pollution-tolerant mollusc in the harbour, living in the contaminated sediments of the Westhaven marina, beneath the Auckland wharves and in the Tamaki Estuary (Hayward *et al.* 1997, M. Morley pers. obs.).

Since it is a new arrival, and now a major member of the Waitemata Harbour ecosystems, it is of interest to find out what impact *Theora lubrica* may be having on the native species and what attributes of its biology have allowed it to colonise so rapidly and successfully these foreign shores.

The life history of *Theora lubrica* has been investigated in its native habitats in Japan (e.g. Tanaka & Kikuchi 1979, Imabayashi & Wakabayashi 1992), but this could differ in its new home. We decided to investigate and document elementary aspects of its life history—growth rate, life span, timing of spawning and density in the substrate.

STUDY SITE

The study site in Hobson Bay (Fig. 1) was easily accessible from the road; but seldom visited by the public (i.e. too muddy). It was exposed at low tide for at least 1-2 days every fortnight, and had sufficient area of substrate to allow for multiple quadrat sampling over many months, without needing to resample the same substrate twice in any one six month period.

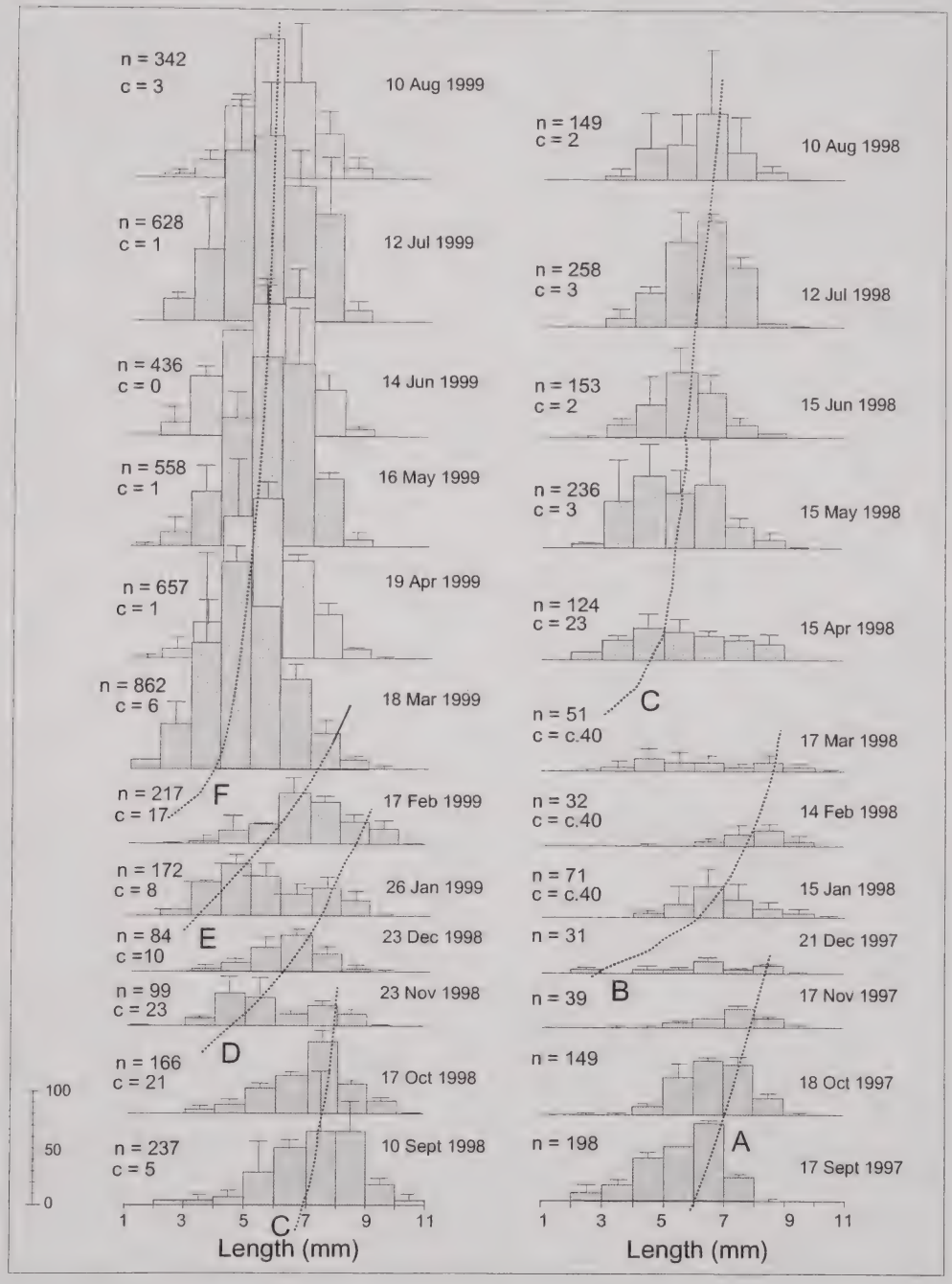

Fig. 7. Histograms showing the monthly size distribution (shell length in mm; frequency expressed as a mean of two replicate samplings of 0.5 m^2) and density (number, n/m^2) of low tidal *Theora lubrica* from Hobson Bay, from September 1997 to August 1999. Bars show standard deviation of numbers in each size class between two replicate quadrat samplings. Dashed lines show interpreted mid-point of successive cohort populations (A to F). Number of crabs, *Macrophthalmus hirtipes* (c) per m^2 is recorded after January 1998.

The study site is on the south side of Purewa Creek estuary where it enters Hobson Bay, 100 m north of Orakei Railway Station. It is immediately seaward of the mud-covered (50-100 mm thick) intertidal tuff rock platform at a tidal height of 0.7 m.

METHODS

The site was visited during a spring low tide every month for 24 months, from September 1997 to August 1999. On each visit, two 0.5 m^2 quadrats were marked on the surface of the mud at approximately the 0.7 m tidal height. In each quadrat the mud was excavated with a spade to a depth of 100 mm and washed on site through a large sieve with 1 mm openings. The coarse fraction retained on the sieve was taken home and all live *Theora lubrica* were sorted into 1 mm size classes based on their shell length and counted. Because of their slim, elongate shape, most *Theora* less than c. 2.5 mm long passed through the sieve.

RESULTS

The monthly patterns of size distribution and change (Fig. 7) were always similar in both quadrats, although density between the two quadrats sometimes varied (resulting in larger standard deviations). During our first year of monitoring *Theora* densities, we observed low densities through the warmer summer months (November 1997 to March 1998, 30-70/m^2) and higher densities through the cooler late autumn to spring months (May to October 1998, 150-250/m^2). The significant drop in density in spring (September to November) of 1997 also occurred in spring (November-December) 1998. The low densities throughout the summer of 1997-98 (December to March) were not repeated in the summer of 1998-99; instead densities progressively increased reaching peak densities of 850/m^2 in March 1999.

Visual inspection of the size histograms (Fig. 7) suggests six cohorts during our 24 months of monitoring. These are labelled as A-F (Fig. 7) and show that spawning occurs intermittently throughout the year with significant recruitmants identified in pre-September 1997 (A), December 1997 (B), March 1998 (C), November 1998 (D), January 1999 (E) and March 1999 (F).

Monthly monitoring of these cohorts indicates that *Theora* have the fastest growth rates in the warmer summer months (c. 2-3 mm/month) and the slowest growth rates through the cooler winter months (c. 0.5 mm/month). The largest *Theora* recorded were in the 10-11 mm length class, with the majority reaching only 9-10 mm. Summer cohorts (B, D, E) appear to live for only 2-3 months, whereas the winter cohorts (C, F) lived for 6-8 months.

DISCUSSION

With warmer sediment temperatures than in New Zealand, even more dramatic die offs of *Theora* have been recorded in summer in Japan and related to temporary oxygen-deficient conditions (Tanaka & Kikuchi 1979). We have no evidence of a similar cause for the Hobson Bay die-back in the 1997-98 summer. It may be related to increased predator pressure and/or a period of low spawning or locally poor settlement.

In the shallow seas of *Theora*'s native range in Japan, its maximum growth rates (6 mm/month), maximum observed density (2000/m^2) and maximum shell size (13-16 mm) are greater (Imabayashi & Wakabayashi 1992) than those observed here. Despite this, there are parallels between the populations in their native land and in their new home. In both places, spawning and recruitment occur intermittently all year, summer cohorts are shorter lived than winter (6 months), growth rates are faster in summer than winter, and significant die-backs may occur in warmer months.

PART 5—SUBSTRATE DEPTH AND INTERTIDAL DISTRIBUTION OF LIVE *THEORA LUBRICA*

(by BWH, MSM)

INTRODUCTION

An important aspect of understanding the ecology and population dynamics of the small introduced semelid bivalve, *Theora lubrica,* is knowledge of how deep it lives within the soft muddy substrate. We could find no published records of this. *Theora* has relatively long thin siphons and is a deposit-feeder. This implies that it probably lives near the surface and no deeper than the length of its extended siphons.

As they mature, some intertidal bivalves are known to migrate to lower tidal levels or even into shallow subtidal depths (e.g. Redfearn 1974, Douglas 1982). If this phenomenon occurs in *Theora lubrica* then it will impact on our interpretation of its population dynamics which we have based on monitoring at a single site (Part 4), c. 0.7 m above extreme low water spring (ELWS) level.

METHODS

The depth to which *Theora* live at our study site in Hobson Bay was investigated during a spring low tide when numbers of individuals were at their peak (3 April 1999). A short length of PVC pipe (36 mm diameter) was pushed into the surface sediment to take short cores. After extraction from the mud, each core was progressively extruded, using a plunger from beneath,

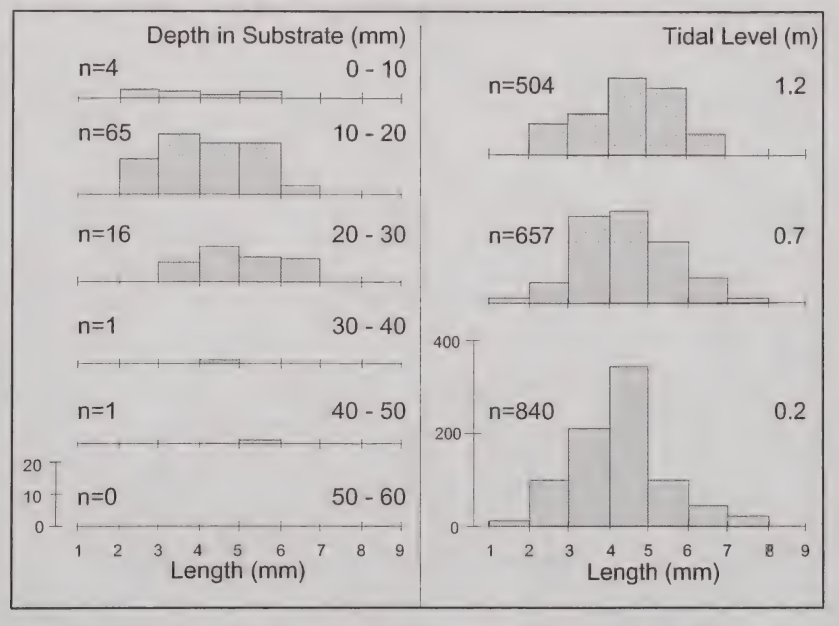

Fig. 8. Left: Histograms showing the size distribution and density (number, n/0.03 m^2) of low tidal *Theora lubrica* from Hobson Bay, at 10 mm intervals in the mud to a depth of 60 mm; results are the total from two replicates on 3 April 1999. Right: Histograms showing the size distribution and density of *Theora lubrica* at different tidal levels (m above ELWS) on the shore of Hobson Bay on 19 April 1999 (results standardised to number, n/m^2).

so that 10 mm thick slices could be cut off and processed separately, down to a depth of 60 mm. After 15 cores had been taken (0.015 m^2), the combined sediment slices from each 10 mm depth interval were washed through a sieve with 1 mm openings. The coarse fractions retained on the sieve were taken home and all live *Theora lubrica* were sorted into 1 mm size classes based on their shell length and counted. A replicate sampling of another 15 cores was also taken.

To investigate whether *Theora* migrate up or down the shore as they mature, their size distribution and abundance were measured at three tidal levels during our usual monthly sampling on 19 April 1999, when bivalve abundances were at their peak. The two usual 0.5 m^2 monthly quadrats were sampled, together with two additional quadrats at tidal heights 0.5 m above and below (1.2 m and 0.2 m) our main study level (0.7 m). In horizontal distance these were 10 m up and down slope from the main site.

RESULTS

No live *Theora* were recorded deeper than 50 mm and only two were recorded deeper than 30 mm (Fig. 8). Over 95% of the live *Theora* were present in the upper 30 mm of sediment, with 60% present at 10-20 mm and 30% at 20-30 mm depth. Few *Theora* were present in the upper 10 mm. The smallest *Theora* (2-3 mm) tend to live at shallower depths than the largest individuals (6-7 mm).

In the Waitemata Harbour, the mean difference between spring and neap low tides is about 0.7-0.8 m. Examination of tide charts indicate that our lowest site at 0.2 m above ELWS is exposed at spring low tide for less than an hour about 6-8 times/year; our main study level at 0.7 m is exposed during low tide on about half of the tides; and our highest site at 1.2 m is exposed at low tide on every tide, for periods of 1-5 hours. Thus our lowest site is essentially shallow subtidal for most of the time.

Our studies showed no significant difference in *Theora* size structure at these three different tidal levels (Fig. 8). Our results suggest a slightly increasing density with distance down the shore (Fig. 8).

DISCUSSION

Some 90% of *Theora lubrica* live 10-30 mm below the surface, with very few deeper than 30 mm. They may burrow deeper when the tide is out. As these measurements were undertaken at low tide, it is possible that *Theora* could live slightly shallower when the substrate is immersed in water.

Our studies suggest that there is no significant migration up or down the shore as *Theora* mature. As our lowest sampling site was essentially subtidal, there is no evidence of movement into the local subtidal zone either. The slightly increased density at lower tidal levels possibly relates to the shorter exposure time during tidal cycles.

PART 6—CRAB PREDATION OF *THEORA LUBRICA*

(by JJH, BWH)

INTRODUCTION

Early results from the monitoring of the population of the introduced bivalve *Theora lubrica* (Part 4) indicated that in some months there were dramatic population declines (e.g. Oct. to Nov. 1997). Such declines could be natural die-offs with old age, or caused by environmental changes (e.g. high temperature, low oxygen), or predation.

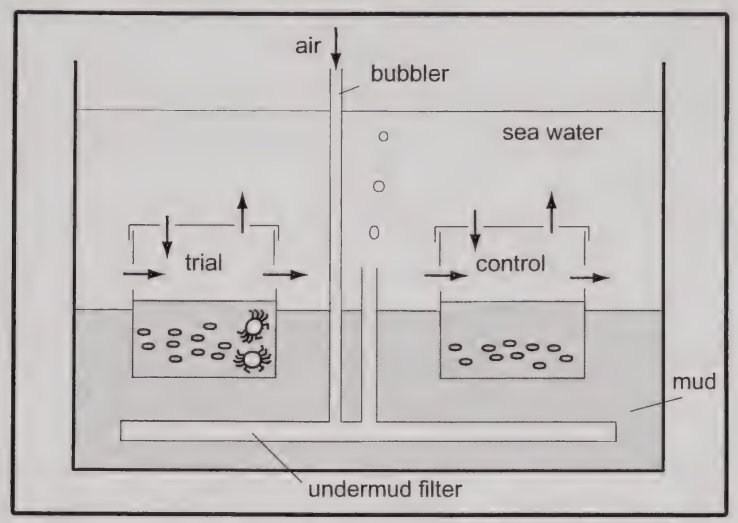

Fig. 9. Diagram of the aquarium for the *Theora lubrica* feeding trials.

Since the decline appeared to be across all size classes, it seemed that old-age was unlikely to be the major cause. We were not monitoring environmental factors, so we focussed on potential predators. Foraging sea-birds are rarely seen in the vicinity of the study site and were therefore unlikely. Bottom-feeding fish (e.g. rays, snapper, flounder) could not be excluded. Within the muddy sediment itself there appeared to be two potential predator species: burrow-dwelling snapping shrimps (*Alpheus richardsoni*) and crabs (*Macrophthalmus hirtipes*). Feeding trials were undertaken in March and April 1998 to investigate the possibility that mud crabs and snapping shrimps might be significant predators of *Theora lubrica.*

METHODS

A small salt-water aquarium was established containing five 150 mm-diameter plastic containers with lids and an aerating bubbler (Fig. 9). The containers and their lids were perforated to allow for water circulation. Mud, collected from the monitoring site in Hobson Bay, was pushed through a sieve with 2 mm openings to remove all crabs, shrimps or sizeable *Theora*, and then placed in the bottom of the aquarium and plastic containers to a depth of c. 80 mm. The aquarium, with containers, was then filled with sea water to a depth of c. 150 mm and left to settle for several days.

Twenty 5-10 mm long *Theora* were placed in each of the five containers and left overnight to burrow into the mud. Next morning one or two potential predators (crabs or snapping shrimps) were placed in each of three containers and the other two were left as predator-free controls.

These feeding trials (with five containers each time) were run three times. After being left undisturbed for 240 hours (2 trials) or 48 hours (1 trial), the mud from each container was passed through a sieve and the number of live *Theora* and crabs or snapping shrimps recorded (Fig. 10).

RESULTS

The four control containers, without crabs or snapping shrimps, retained 80-100% of their

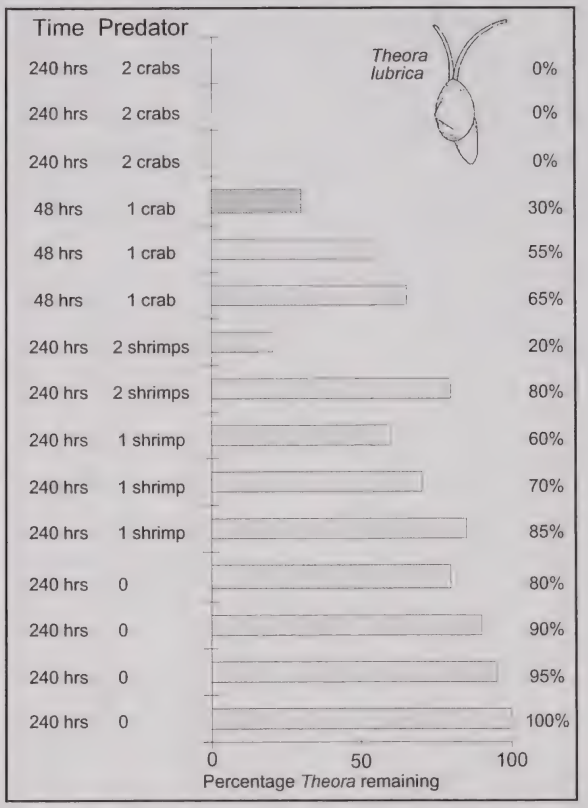

Fig. 10. Bar graphs showing the results of the feeding trials (with controls), to test whether the crab *Macrophthalmus hirtipes* and/or the shrimp *Alpheus richardsoni* feed on the small introduced bivalve *Theora lubrica.*

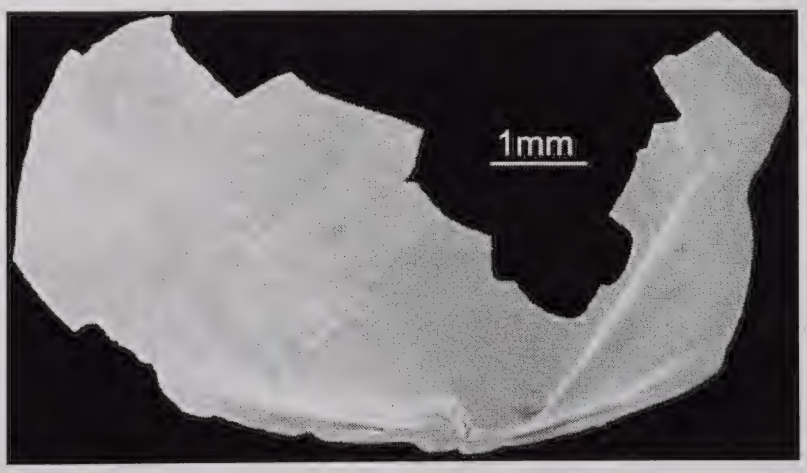

Fig. 11. Scanning electron micrograph of a valve of *Theora lubrica* (recovered from one of our feeding trials) that has been chewed by the chela of the crab *Macrophthalmus hirtipes.*

original 20 live *Theora* after 240 hours (Fig. 10). The three containers with one snapping shrimp each, retained 60-85% of their original 20 live *Theora* after 240 hours. The two containers with two snapping shrimps each retained 20-80% after 240 hours. All three containers with two crabs each, had no live *Theora* remaining after 240 hours. Three containers with one crab each, retained 30-65% of the original live *Theora* after a mere 48 hours. Fragments of thin *Theora* shells with jagged (apparently crushed) edges (Fig. 11) were recovered from some of the containers with crabs, and suggest that the strong crab chelae are easily capable of breaking the *Theora* shells.

After suspecting that crabs might be influencing the *Theora* population densities, we began monthly monitoring of all associated macrobiota in our quadrats in April 1998 (Fig. 7). We recalled relatively high crab numbers (c. 40/m^2) for at least the three preceeding months. Subsequent monitoring showed the density of the crab *Macrophthalmus hirtipes* fluctuated from a low of 0-3/m^2 in cooler months (May to August 1998) to a peak of 30-40/m^2 in warmer months (December 1997 to March 1998).

DISCUSSION

There appears to be a small background loss of *Theora* resulting from their translocation and confinement in the aquarium. Feeding trials using snapping shrimps provided rather variable results that can be interpreted as negligible to moderate predation rates on *Theora.*

Feeding trials using the mud crab *Macrophthalmus hirtipes* provided convincing evidence that they are a major predator of such a small, fragile bivalve. The 240 hour trials show an average minimum feeding rate of one *Theora*/crab/day. The 48 hour trials gave a range of 3.5-7 *Theora* consumed/crab/day. It is possible that the artificial aquarium conditions could have stressed the *Theora*, and made them more susceptible to predation. These consumption rates, if repeated in nature, could account for much of the large population decline sometimes recorded.

During the period of major *Theora* decline in summer 1997-1998, bivalve densities fell over a two month period from 200 to 40/m^2. At the same time densities of c. 40 *Macrophthalmus* crabs/m^2 were present in the study quadrats. If all the lost *Theora* resulted from crab predation, the consumption rate would have averaged 0.07 *Theora*/crab/day, well within the crabs' capability documented in our feeding trials. The much higher consumption rate in our feeding trials from that apparent in the wild, may in part be due to the higher density of *Theora* in our trials (1000/m^2) and the lack of other replenishing food resources in our trials compared with natural tidal conditions.

These fluctuating densities pose several questions. Are they natural seasonal fluctuations independent of the introduced *Theora*? Is predation by native crabs controlling the density of introduced *Theora*? Is the presence of large densities of the recently introduced food source, *Theora*, increasing densities of crab predators? If so, is this resulting in other downstream effects on the ecosystem?

We have insufficient data to answer most of these questions. Observations elsewhere have shown that crab numbers naturally increase in spring and summer and decline over winter (ABS pers. obs.). Our monitoring shows this same seasonal pattern. This suggests that variations in *Theora* densities are not the primary cause of our observed seasonal variations in crab numbers. The two years of monitoring suggests that higher crab densities (e.g. summer 1997-98) are correlated with lower *Theora* densities (e.g. summer 1998-99) and that to some extent crab predation controls the density of *Theora.*

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APPENDIX 1. Census data of live fauna (retained on 1 mm sieve) from monitoring dredge sampling of the subtidal station off the west end of Cheltenham Beach, from 27 July1993 to 25 February 1997. Expressed as number of specimens/0.15 m^2 of sea floor. Last four sampling results are the mean of four replicates. Results for 8.8.95 lack data from the 1-2 mm size fraction and are therefore incomplete and not included in the analysis of faunal trends (Figs 2, 3).

Survey date	27.7.93	19.11.93	10.2.94	3.6.94	23.9.94	8.8.95 mean	23.1.96 mean	17.9.96 mean	25.2.97 mean
POLYPLACOPHORA									
Leptochiton inquinatus	0	0	0	0	0	0	1.25	0	0
GASTROPODA									
Austromitra rubiginosa	0	0	0	0	0	1	0	0	0
Cominella adspersa	1	2	0	0	0	0	0	0.25	0.25
Cominella quoyana	0	0	0	0	0	0.5	0.25	0	0
Eatoniella roseola	0	0	0	0	0	0.25	0	0	0
Epitonium minora	0	0	1	0	0	0	0	0	0
Maoricolpus roseus	0	0	0	0	0	0.75	0.25	0	0
Neoguraleus murdochi	0	0	0	0	0	0.5	0	0	0
Philine sp.	0	0	0	0	0	0.5	0	0	0
Trichosirius inornatus	0	0	0	0	0	0.25	0	0	0
Zeacolpus pagoda	0	0	0	0	0	0.75	0	0	0
Zegalerus tenuis	1	0	0	0	0	0	0	0	0
Zemitrella choava	0	0	0	0	0	0.25	0	0	0
BIVALVIA									
Arthritica bifurca	0	0	12	47	2	0.25	11	0	0
Corbula zelandica	0	0	7	8	0	0	1.25	0.5	1.25
Cyclomactra ovata	0	0	0	0	0	0	0	0.25	0
Dosina zelandica	0	0	0	0	0	0	0	0	0.25
Dosinia lambata	0	0	0	1	0	0	0.25	0	0
Felaniella zelandica	2	1	24	6	4	0	1.5	0	0.5
Gari stangeri	0	0	0	0	0	0	0	0	0.25
Leptomya retiaria	2	0	5	0	0	0.25	0.5	0	0.5
Melliteryx parva	0	0	0	20	5	0	7.5	0	0
Musculista senhousia	32	24	0	2	0	0	0	0	0
Nucula hartvigiana	0	1	2	6	2	0.5	1.75	0.5	0.25
Nucula nitidula	2	0	2	0	0	0.25	1.5	0	0
Pleuromeris zelandica	0	0	0	0	0	0	1.25	0	0.75
Purpurocardia purpurata	0	0	0	2	0	0	0	0	0
Ruditapes largillierti	6	1	4	2	0	0.5	0.5	0.25	0
Scintillona zelandica	1	0	1	0	3	0	2.25	0	0
Tawera spissa	2	1	0	9	0	0	1.25	0.5	0.25
Theora lubrica	0	0	1	0	2	1.75	1	0	0
Zenatia acinaces	0	0	0	0	0	0.25	0.25	0	0.25
OPHIUROIDEA									
Amphiura roseus	0	0	0	0	0	0.25	0.75	0	0
Amphiocnida pilosa	1	0	0	0	0	0.25	0	0	0
Amphiopolis squamata	0	0	0	1	1	0	0.75	0	0
HOLOTHURIA									
Trochodota dendyi	16	9	7	3	26	0.25	0.25	0	2

Survey date	27.7.93	19.11.93	10.2.94	3.6.94	23.9.94	8.8.95 mean	23.1.96 mean	17.9.96 mean	25.2.97 mean
REPTANTIA									
Halicarcinus sp.	0	0	0	0	0	0	0.25	0	0
Halicarcinus varius	1	2	0	0	3	0	0.25	0	0
Helice crassa	0	2	0	0	0	0	0	0	0
Macrophthalmus hirtipes	4	9	4	4	74	0	1	0	0
Notomithrax minor	1	0	0	0	0	0	0	0	0
Paguristes pilosus	0	0	2	1	0	0.75	2.25	0.25	0
Pagurus sp.	0	0	1	0	0	0	0	0	0
Pinnotheres atrinocoloa	0	0	0	0	2	0	0	0	0
Pyromaia tuberculata	0	0	0	0	0	0	0.25	0	0
Upogebia danai	0	0	0	0	0	0	0	0.25	0
Upogebia hirifrons	0	0	0	3	0	0	2.75	0.25	2.75
Upogebia sp.	2	0	0	0	0	0	0	0.25	0
DECAPODA									
Callianassia filholi	0	0	0	0	0	0	0.25	0	0.5
Callianassia sp.	0	0	0	0	0	0	0.5	0	0
Palaemon affinis	1	0	0	1	0	0	0	0.25	0
Pontophilus australis	0	3	0	0	0	0	0	0	0
ISOPODA									
Natatolana albicaudata	7	6	4	5	0	0	0.75	2.25	0.5
Natatolana nammuldi	0	0	0	0	1	0	0	0	0
Natatolana sp.	0	0	0	0	0	0	0	0	0.25
AMPHIPODA									
Ampelisca chiltoni	0	0	0	0	0	0	0	1.25	0
Ampelisca sp.	1	1	2	6	0	0	1	0	0
Corophium sextonae	0	0	1	0	1	0	0	0	0
Elasmopus sp.	1	0	0	2	0	0	0	0	0
Liljeborgia akaroica	0	0	0	0	0	0	0.5	0	0
Maera mastersi	0	0	0	0	0	0	0.25	0	0
Melita awa	0	0	0	1	2	0	0	0	0
Melita festiva	2	0	0	0	0	0	0	0	0
Melita sp.	0	0	0	0	0	0	0	0	0.5
Metaphoxus sp.	0	0	0	0	3	0	0	0	0
Paradexamine pacifica	0	4	0	0	2	0	0	0	0
Paradexamine sp.	0	4	0	0	0	0	0	0	0
Paraperioculodes sp.	0	0	0	0	1	0	0	0	0
Parawaldeckia sp.	0	0	0	0	0	0	0	0	0.25
Parawaldeckia thomsoni	3	0	0	0	2	0	0.25	1.25	1.25
Proharpinia sp.1	0	0	0	0	8	0	1.75	0	0
Proharpinia sp.2	0	0	0	0	0	0	0	3.25	0
Protophoxus australis	0	0	0	0	0	0	0	0.5	0.5
Torridoharpinia hurleyi	1	6	0	0	1	0	0	0.25	0
TANAIDACEA	0	0	0	1	0	0	0	0	0
LEPTOSTRACA	0	0	0	0	0	0	0.25	0	0
OSTRACODA									
Diasterope grisea	0	0	4	0	0	0	4	3.25	2
Scleroconcha arcuata	0	0	1	0	0	0	0	0	0
Ostracoda indet.	3	7	0	2	0	0	0	0	0

Survey date	27.7.93	19.11.93	10.2.94	3.6.94	23.9.94	8.8.95 mean	23.1.96 mean	17.9.96 mean	25.2.97 mean
POLYCHAETA									
Aglaophamus macroura	0	0	1	1	2	0	3.25	3	1.25
Amphicteis philippinarum	0	3	1	2	3	0	0	0	0.25
Armandia maculata	0	0	8	4	1	0	0.25	0.5	0
Asychis sp.	0	0	0	0	0	0	0	0	0.5
Axiothella quadrimaculata	30	43	62	57	13	0	3.5	0	0
Boccardia syrtis	0	0	0	0	1	0	3.25	2.5	0.25
Bradabyssa sp.	0	0	0	0	0	0	0	0	0.25
Capitellid indet.	24	14	64	63	21	0.5	17.75	1	0
Cossura sp.	0	0	0	1	0	0	0	0	0
Diopatra akarana	0	0	0	1	0	0	0	0	0
Euchone sp.	5	1	0	3	0	0	0	0	0.25
Eupholoe sp.	1	0	0	2	0	0	0	0	0
Glycera americana	0	0	0	1	2	0.25	0	0	0
Glycera ?lamelliformis	0	0	2	0	0	0	0	0	0
Glycera lamellipodia	6	4	7	2	3	0	0.25	0.25	0.25
Goniada dorsalis	1	3	12	0	0	0.75	4	2	0.25
Lepidastheniella sp.	1	0	3	1	1	0.25	0.5	0.5	0
Lumbrineris coccinea	0	0	0	0	0	0	0	0	0.25
Magelona papillicornis	0	0	0	0	0	0	0.25	0.25	0
Maldanid indet.	0	0	1	0	1	0.75	1	0	0
Marphysa depressa	0	0	1	0	0	0	0	0	0.25
Nereid indet.	0	0	1	1	1	0	0	0	0
Ninoe leptognatha	0	1	0	0	0	0	0	0	0
Onuphus aucklandensis	0	0	0	0	0	0	0	0.25	0
Ophiodromus angustifrons	0	0	1	0	0	0	0	0	0
Orbinia papillosa	0	1	1	4	0	0.25	0.5	0	0.25
Paraboccardia sp.	0	1	0	3	0	0	0	0	0
Paraprionospio sp.	0	5	7	1	0	0	1.25	0.25	0.25
Pectinaria australis	5	0	1	3	1	1.75	0.5	0.25	0.5
Phyllodocid indet.	1	0	0	0	0	0	0	0.5	0.25
Pomatoceros caeruleus	0	0	1	2	0	0	0	0	0
Prionospio sp.	7	4	8	10	17	0	2	3	0
Pseudopolydora sp.	0	0	1	4	0	0	0	0	0
Schistomeringos sp.	0	1	0	0	0	0	0	0	0
Spionid indet.	0	1	0	0	2	0	0	0	0
Terebellanice sp.	6	3	4	3	1	0.25	0	1	0.25
Terebellid indet.	0	0	0	0	0	0	0.5	0	0
Timarete sp.	0	0	0	0	0	0	0	0	0.25
PHORONIDA									
Phoronis sp.	0	0	1	0	0	0	0	0	0
NEMERTEA									
black nemertine	0	3	0	0	0	0	0	0	0
Nemertea indet.	5	6	0	0	0	0.5	0.5	0	0
SIPUNCULIDA									
Dendostomum aeneum	1	0	0	0	0	0	0	0	0

INNER SHELF MOLLUSCA OF THE BAY OF ISLANDS, NEW ZEALAND, AND THEIR DEPTH DISTRIBUTION

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Abstract. The Bay of Islands on the east coast of Northland, has the most diverse molluscan fauna of any area of similar size in New Zealand. We record 551 mollusc species (389 gastropods, 139 bivalves, 20 chitons, 2 scaphopods and 1 shelled cephalopod) from intertidal to 60 m depths, estuarine to exposed oceanic, rocky shores to muddy seafloor. The high diversity is a result of the wide range of habitats present and the area's location within the warm waters of the Aupourian Province (east coast of the northern North Island). Indeed 192 Bay of Islands species appear to be largely restricted in New Zealand to this province. At least three subtropical gastropods (*Terebra circumcincta*, *Phenacovolva wakayamaensis*, *Natica lemniscata*) have arrived naturally, established small populations, and then after several years apparently died out in the Bay of Islands. Four bivalves (*Crassostrea gigas*, *Limaria orientalis*, *Musculista senhousia*, *Theora lubrica*) and one gastropod (*Microtralia occidentalis*) are believed to be exotic species introduced by shipping. The depth ranges of live molluscan specimens and their dead shells, together with those of other hard-shelled invertebrates, have been compiled from 330 dredge samples from throughout the Bay, supplemented by numerous intertidal and snorkel surveys around shallow rocky areas.

KEYWORDS: Mollusca; New Zealand; Bay of Islands; biogeography.

INTRODUCTION

Most of the shallow water, inner shelf (0-50 m depth), molluscs of mainland New Zealand are now described (Powell 1979; Spencer and Willan 1996) and their broad biogeographic distribution patterns around the country are moderately well understood (e.g. Powell 1955, 1979; Spencer and Willan 1996), but their ecological distribution is poorly documented, except for those living in intertidal habitats (e.g. Morton and Miller 1968). The most simplistic variable used in describing the ecological distribution of subtidal molluscs is their depth range, but even this is poorly recorded.

The depth ranges of modern molluscs is particularly useful in paleoenvironmental interpretations of fossil assemblages (e.g. Beu and Maxwell 1990, Eagle *et al.* 1995). This depth data is currently not easy to find, with one of the main sources still being the observations 60 years ago in the Waitemata Harbour by Powell (1937). An offshoot of our extensive dredge surveying of the seafloor biota of the Bay of Islands (unpub.) is the generation of a major data set on the depth distribution of hundreds of mollusc species and other hard-shelled marine invertebrate remains.

In Appendix 1 we present the depth ranges of both the live and dead shells. We recognise that the dead shells are in some places subject to post-mortem transport by strong bottom

currents or storm waves but this is not so widespread as to homogenise or hide the original depth distribution patterns. Large-scale post-mortem transport occurs in the Bay of Islands only in the shallows (c. 0-5 m) along exposed shores and in narrow, current-swept channels. In many instances it results in the abrasion of heavy shells and loss of more fragile ones. Presenting both the recorded live and dead range of shells is particularly useful for paleoecological studies that will be based upon them. For rarer species for which we have recorded few if any living specimens (e.g. *Anisodonta alata, Austrofusus glans, Myllita stowei*), the dead range often supplies a good indication of the possible live depth ranges. For more abundant species which have a dead range far exceeding the recorded living range (e.g., *Crepidula costata, Chlamys zelandiae, Myadora striata, Tucetona laticostata*), it may be suggesting that the species lives in high energy environments where the shells are often transported away after death. If the dead range of an abundant species is very similar to the living range (e.g., *Epitonium minora, Moerella huttoni, Nucula hartvigiana*), it may be that the species is living in quieter, finer sediment habitats where the shells are seldom swept away. Similar patterns can be expected in the fossil record.

Previous documentation of the ecological distribution of some molluscs in the Bay of Islands is contained in a study of the soft bottom biota in the shallows around Urupukapuka Island (Hayward *et al.* 1981) and this has been incorporated into this study.

STUDY AREA

The area covered by this report is the greater Bay of Islands (ca. 35°15'S, 174°12'E), encompassing everything landward of a line joining Cape Brett and Piercy Island in the east to Ninepin Island and Purerua Peninsula in the north (Fig. 1). The only substantial part of the Bay of Islands not surveyed was the upper part of the Kerikeri Arm in the north-west. The Bay of Islands is a drowned river valley with tributaries, which has resulted in many small embayments, islands and estuaries. Depths range from 50-60 m in the exposed open mouth of the bay to intertidal, mangrove-fringed mud flats around the head of many of its arms. Substrates range from hard greywacke and basalt shorelines through coarse subtidal shell or rhodolith gravels and clean sands to soft intertidal mud and muddy fine sand in the deeper parts.

METHODS

The data on molluscan occurrence and distribution summarised in this paper has been assembled from a combination of dredge samples, shallow subtidal snorkel surveys and intense intertidal surveys undertaken during six weeks of field work by the Auckland Museum Marine Department from 1992 to 1997. We took 330 dredge samples from subtidal depths, 0-60 m below sea level, using a 10 litre capacity rectangular bucket dredge that generally penetrated 5-10 cm into the seafloor sediment, depending on its hardness. The snorkel and intertidal surveys mostly targeted rocky habitats, but included beaches, to supplement the dredge data on the soft substrate fauna. These latter surveys included micromollusc searches in sediment samples from under rocks, seaweed washes and rock washes.

Sediment retrieved by dredging was passed through a sieve with 1 mm openings and all live molluscs retained were identified and counted. A complete species list of dead shells with a qualitative assessment of abundance was also prepared from the sediment residue from each dredge station. For the purposes of this report, the quantitative data on live molluscs has also been converted to a qualitative assessment of abundance. During each snorkel and intertidal survey a molluscan species list with a similar qualitative assessment of abundance of live and dead specimens was compiled. All these results have been combined and are presented in qualitative abundance classes at 5-20 metre depth intervals in Appendix 1.

Voucher specimens of each species are lodged in the collections of the Auckland War

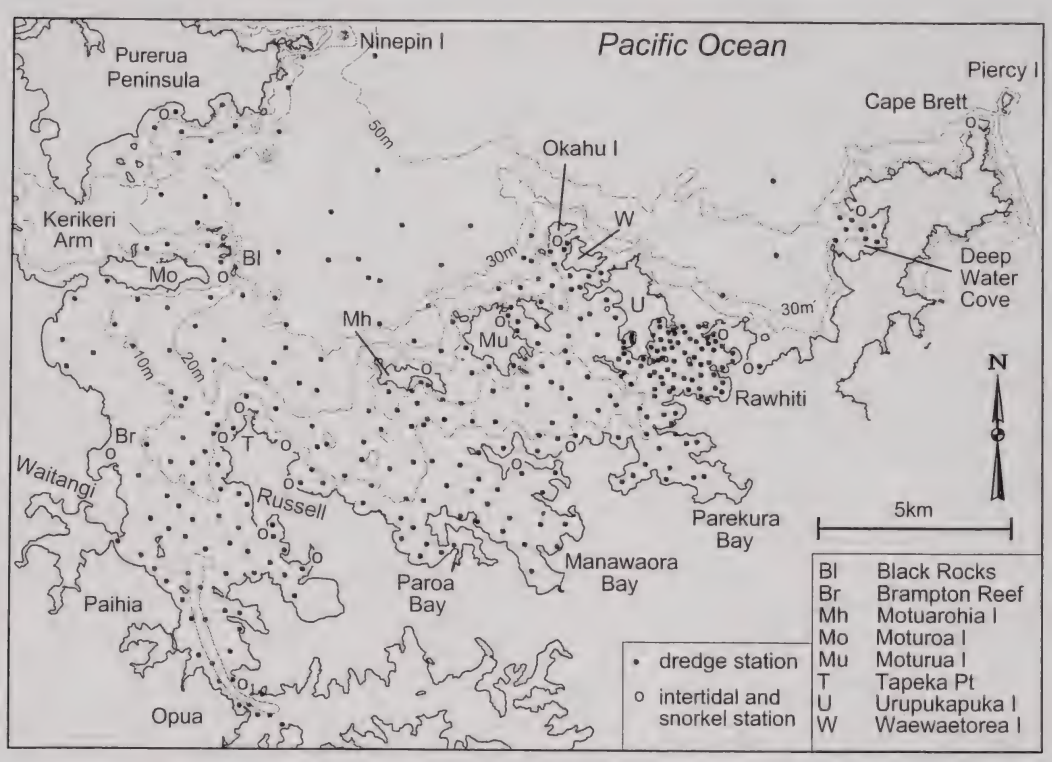

Fig. 1. Bay of Islands, showing location of the 330 dredge stations and numerous intertidal and shallow subtidal snorkel surveys upon which most of the depth ranges in this paper are based.

Memorial Museum, and registration numbers are given where appropriate (e.g., AK130909 for *Terebra circumcincta*).

SPECIES DIVERSITY AND BIOGEOGRAPHY

We record 551 mollusc species from the Bay of Islands (Appendix 1). This can be compared with the number of species recorded through extensive studies of three smaller areas also on the northeast coast of the North Island: 351 species from sand dredged from 40 m depth off Pakiri (Morley, Goulstone *et al.* 1997); 340 species from Oneroa Bay, Waiheke Island (Morley unpub.); and 167 species recorded from the central and upper Waitemata Harbour (Hayward *et al.* 1999). All three areas have a narrower range of habitats and are smaller than the Bay of Islands and this contributes to their lower species diversity.

Lower levels of molluscan diversity have also been recorded from large areas on the west coast of the North Island—192 species from around Kawerua, west Northland (Hayward *et al.* 1995); 192 species from Kawhia area (Morley, Hayward *et al.* 1997) ; and 197 species from the coast of northern Taranaki (Hayward *et al.* in press).

Still further south, in an area of similar size and habitat diversity to the Bay of Islands, 367 molluscs (not including soft-bodied cephalopods) have been recorded from Wellington Harbour and its approaches (Marshall 1998). The Wellington records include 19 chitons, 231 gastropods and 114 bivalves, which compare with 20, 389 and 139 respectively from the Bay of Islands.

There are 249 species (12 chitons, 153 gastropods, 82 bivalves) common to both Wellington and the Bay of Islands. Thus a far greater percentage of gastropods appear to prefer the warmer waters of the Bay of Islands, than any of the other mollusc classes.

The Bay of Islands probably has the highest diversity of shallow-water molluscs for any area of this size in New Zealand. There are several reasons for this high diversity:
1. The location on the north-east coast of Northland within the warm-water Aupourian Province—the New Zealand biogeographic province with the highest diversity of molluscs.
2. The area extends from marginally oceanic conditions on the fringe of the eddies of the warm East Auckland Current, to shallow water neritic and brackish conditions.
3. There is a wide range of habitats from sheltered, muddy estuarine to exposed, marginally oceanic, rocky shore. The only major nearshore habitats that are largely lacking are rocky shores soft enough for rock borers, and exposed oceanic beaches for surf clams.
4. The water quality is generally high and little impacted by human-induced pollution and increased sedimentation.

SUBTROPICAL VISITORS (Fig. 2)

The warm waters of the south-flowing East Auckland Current periodically introduce tropical or subtropical molluscs and other marine biota to the east coast of Northland (e.g. Powell 1976). Most of these have been recorded from localities, like the Poor Knights Islands, which are more in the path of the current, but eddies sometimes impinge on Cape Brett peninsula at

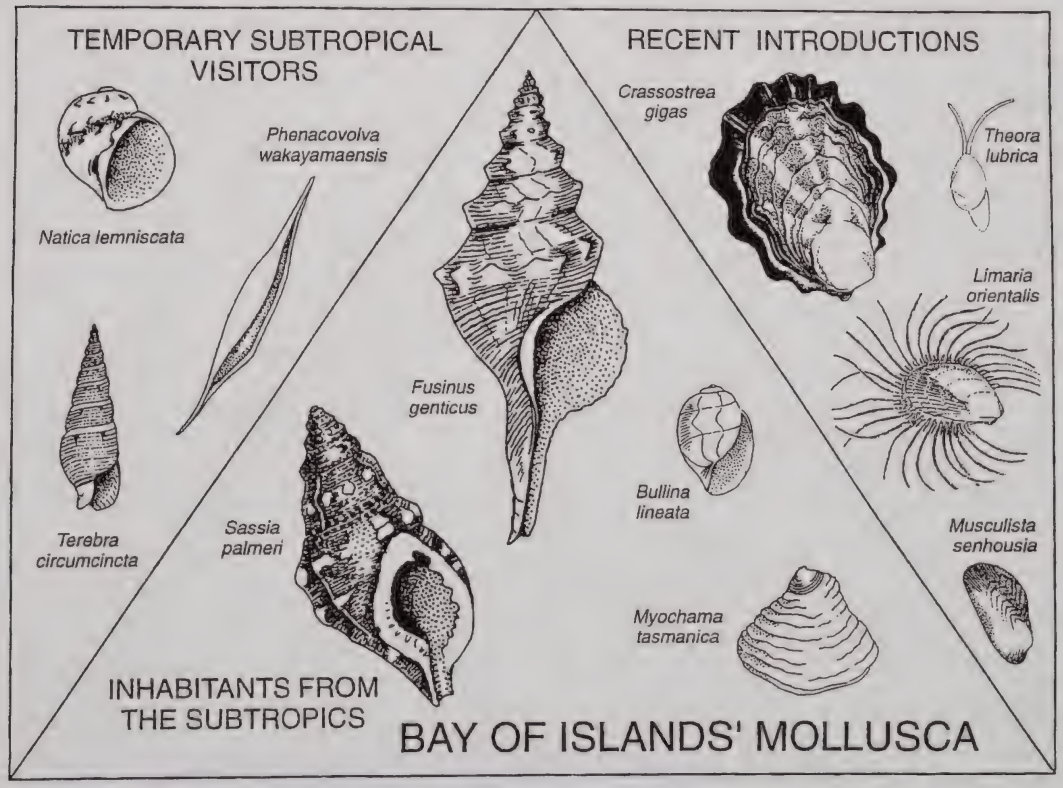

Fig. 2. Examples of subtropical and introduced molluscs recorded from the Bay of Islands.

the entrance to the Bay of Islands, and have introduced a few warm-water species.

Three such species that have been introduced to the Bay of Islands by warm currents, and that bred for a season or two and established small populations, now appear to have died out. These are:

1. *TEREBRA CIRCUMCINCTA*. A small population (AK130909) was found living in the warm subtidal shallows of Waewaetorea Channel in the 1970s and early 1980s (Powell 1979), but it could not be found at this locality alive or dead in the mid 1990s.
2. *PHENACOVOLVA WAKAYAMAENSIS*. A small population was living on gorgonians off Cape Brett Peninsula in the early 1990s, but had disappeared a few years later (Fred. Brook pers. comm.). It has also been recorded from the Poor Knights Islands (Powell 1979).
3. *NATICA LEMNISCATA*. Three specimens were washed up on the beach at Urupukapuka Island and recorded by Powell (1979, as *N. sagittata hancockae*); and one was found by us on Okahu Island (AK89611) in 1994. Shells have also been found at the Poor Knights Islands and Cape Karikari (Fred Brook pers. comm.).

The Bay of Islands species list includes a group of subtropical taxa, largely restricted to, and rare within, the Aupourian Province:

1. *ACTEON CRATICULATUS* and *A. MILLERI*. Dredged from 21 and 38 m depth off Moturua Island near the middle of the Bay of Islands (AK100859,102006). Elsewhere in New Zealand *A. craticulatus* has been sporadically recorded off the east coast of the northern North Island as far south as Gisborne (Auckland War Memorial Museum collections), and *A. milleri* has been recorded from off Pakiri (Morley, Goulstone *et al.* 1997).
2. *BULLA ANGASI*. Found washed up on Motuarohia Island (AK133208) and dead at 10 m depth (this study). Elsewhere in New Zealand recorded in beach wash-ups between Cape Maria van Diemen and Whangarei (Powell 1979).
3. *BULLINA LINEATA*. Dredged from 38 m depth near the centre of the open mouth of the Bay of Islands (AK131267) and seen alive at 6 m depth off Urupukapuka Island during a SCUBA dive in 1985 (Steve O'Shea pers. comm.). There are sporadic records down the east coast of Northland to the Bay of Plenty (Powell 1979, Morley, Goulstone *et al.* 1997).
4. *CASMARIA PERRYI*. Observed live at 5 m depth off Cape Brett Peninsula in 1991 (Fred Brook, pers. comm.). Also known in New Zealand from Great Barrier Island (Powell 1979).
5. *FUSINUS GENTICUS*. One live specimen (AK139772) was collected by Kevin Burch at 30 m depth in Deep Water Cove during a SCUBA dive in 1998. Elsewhere recorded sporadically off the east coast of northern Northland (Morley unpub.).
6. *NASSARIUS SPIRATUS*. Found washed up on Okahu Island (AK131231) and in a dredge haul from Deep Water Cove. There are other rare records along the east coast of Northland from North Cape to Great Barrier Island (Powell 1979, Morley unpub.).
7. *NATICA MIGRATORIA*. Found washed up on Okahu Island (AK89610). Elsewhere in New Zealand recorded from Parengarenga Harbour and a few scattered localities down the east coast of Northland and Coromandel (Powell 1979, Morley unpub.).
8. *POLINICES SIMIAE*. Found washed up at Tapeka Point (Powell 1979) and on Motuarohia Island (AK133218, this study). Elsewhere in New Zealand recorded dead from a few localities down the east coast of Northland and the Bay of Plenty (Powell 1979).
9. *NOVASTOA LAMELLOSA*. This colonial vermetid gastropod lives attached to low tidal basalt on the Black Rocks in the Bay of Islands (AK149002). Elsewhere it occurs at the Moturoa, Poor Knights, Great Mercury, White and Chatham Islands (Grace and Puch 1977, Powell 1979).
10. *POLINICES TAWHITIRAHIA*. Recorded from shallow water in the Bay of Islands (Powell 1979). Not found during this survey, but observed at 10 m depth off Cape Brett Peninsula in 1994 (Fred Brook, pers. comm.). Elsewhere in New Zealand recorded from the Cavalli and

Poor Knights Islands (Powell 1979).
11. *SASSIA PALMERI*. Found dead at 18 m depth off Cape Brett Peninsula (Fred Brook, pers. comm.). Elsewhere in New Zealand recorded from the Poor Knights Islands and off Pakiri (Powell 1979, Morley, Goulstone *et al.* 1997).
12. *SASSIA PARKINSONIA*. Recorded living in Deep Water Cove (AK75044) and washed up on Okahu Island (AK90122) in the Bay of Islands in 1981 (Morley unpub.). Elsewhere recorded sporadically along the east coast of Northland and Bay of Plenty (Powell 1979).
13. *SEMICASSIS ROYANUM*. Seen live at 25 m off Cape Brett Peninsula in 1992 (Fred Brook, pers. comm.). Elsewhere in New Zealand observed live at the Poor Knights Islands (Powell 1979).
14. *TUTUFA BUFO*. Dead shell collected by Steve O'Shea during a SCUBA dive off Moturoa Island in 1984 (Morley unpub.) and live juveniles seen by Fred Brook at 20 m depth off Cape Brett Peninsula in 1994. Elsewhere in New Zealand recorded from Spirits Bay, Parengarenga Harbour, Doubtless Bay and the Poor Knights Islands (Powell 1979).
15. *MYOCHAMA TASMANICA*. Dredged from the middle of the entrance to the Bay of Islands in 38 and 44 m water depth (AK100851). Elsewhere in New Zealand recorded only from Parengarenga Harbour (Powell 1979), where it occurs in shallower depths.

Not recorded here from the Bay of Islands, however, are a number of other subtropical "visitors" that have arrived naturally off Northland's east coast in recent decades e.g. *Aglaja lineolata, Conus lischkeanus kermadecensis, Epitonium lamellosa, Hydatina albocincta, Neothais clathrata, Semicassis sophia, Tonna cumingii, T. maculata* (e.g., Powell 1976).

WARM-WATER AUPOURIAN-RESTRICTED SPECIES

In addition to the subtropical species mentioned above, many other mollusc species living in the Bay of Islands have a New Zealand distribution limited to the warm waters of the Aupourian Province. Indeed, 35% (192 species) of the Bay of Islands' molluscs are restricted to the Aupourian Province. These are dominantly gastropods (163 species), with fewer Aupourian-restricted bivalves (28 species) and chitons (1 species).

INTRODUCED EXOTIC SPECIES (Fig. 2)

Four of the bivalves recorded here from the Bay of Islands have been introduced to New Zealand within the last three decades and are now widespread along the north-east coast of the North Island and have had a major impact on the biota of the Waitemata Harbour, Auckland (Hayward *et al.* 1997, Hayward 1997). These are the Pacific oyster (*Crassostrea gigas*) which lives in great abundance on intertidal rocks and in several oyster farms in the Bay of Islands; the Asian mussel (*Musculista senhousia*) which lives in small transient thickets in Otehei (Urupukapuka Island), Parekura, Manawaora and adjacent bays; the small Asian semele (*Theora lubrica*) which lives in large numbers in shallow muddy sediments throughout most of the bay; and the file shell (*Limaria orientalis*) which is widespread in the subtidal shallows in many parts of the Bay of Islands.

The gastropod *Microtralia occidentalis*, present in the Bay of Islands, has probably also been introduced to New Zealand by humans (Climo 1982). It lives around high tide mark and also occurs around the fringes of the Waitemata Harbour (Hayward 1997, Hayward *et al.* 1999).

DEPTH RANGES

Bay of Islands depth ranges are given in Appendix 1. We have not searched the literature to determine the total known depth range of taxa that also live deeper than 60 m outside the study area. The subtidal ranges are based almost exclusively on soft substrate dredge records

and thus the depth ranges of harder substrate inhabitants are under-reported.

Although this study is limited to intertidal and inner shelf depths (0-60 m), there are many taxa that are restricted to only part of this depth range. Here we have grouped together the more abundant or characteristic taxa of these restricted depth zones, citing total depth range, followed by live depth range in italics.

INTERTIDALLY-RESTRICTED, ON ROCKS AND SEAWEED (Fig. 3)

Chiton: *Sypharochiton pelliserpentis.*
Gastropods: *Diloma* spp., *Haustrum haustorium, Lepsiella scobina, Melagraphia aethiops, Micrelenchus tenebrosus, Nerita atramentosa, Nodilittorina antipodum, N. cincta, Notoacmea helmsi, N. parviconoidea, N. pileopsis, Novastoa lamellosa, Onchidella nigricans, Patelloida corticata, Risellopsis varia, Siphonaria australis, Zeacumantus subcarinatus.*
Bivalves: *Crassostrea gigas, Saccostrea cucullata, Xenostrobus pulex.*
Barnacles: *Chamaesipho brunnea, C. columna, Epopella plicata, Elminius modestus.*

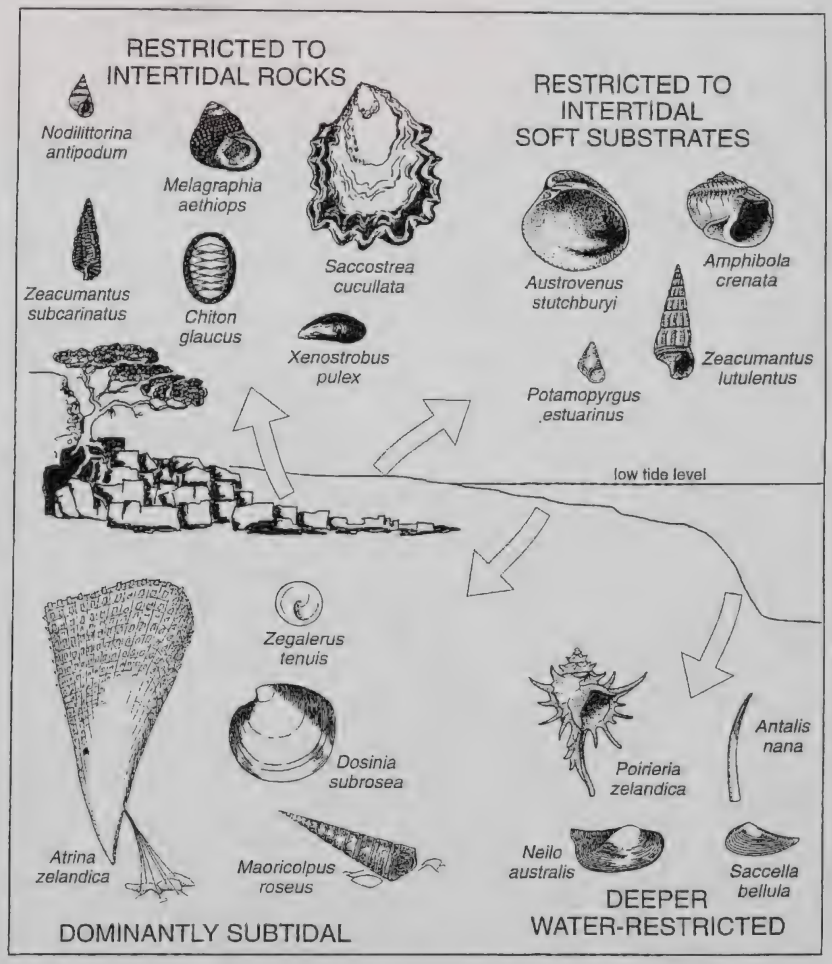

Fig. 3. Schematic diagram showing a selection of more common or characteristic molluscs of various habitats and depths in the Bay of Islands. Several illustrations are from Powell (1947).

INTERTIDALLY-RESTRICTED, ON SOFT SUBSTRATES

Gastropods: *Amphibola crenata, Diloma subrostrata* (on shells or stones), *Potamopyrgus estuarinus, Zeacumantus lutulentus.*

INTERTIDAL AND SHALLOW SUBTIDAL (Fig. 3)

Chitons: *Acanthochitona zelandica* (0-8 m, *0-8 m*), *Chiton glaucus* (0-5 m, *0-2 m*), *Ischnochiton maorianus* (0-14 m, *0-14 m*).
Gastropods: *Amalda novaezelandiae* (0-44 m, *0-40 m*), *Bulla quoyii* (0-12 m, *0-7 m*), *Cantharidus purpureus* (0-31 m, *0-5m*), *Cellana stellifera* (0-11 m, *0-2 m*), *Cominella adspersa* (0-18 m, *0-18 m*), *Cominella quoyana* (0-32 m, *0-32 m*), *Neoguraleus murdochi* (0-29 m, *0-5 m*), *N. lyallensis* (0-31 m, *0-6 m*), *Pervicacia tristis* (0-22 m, *0-12 m*), *Rissoina chathamensis* (0-16 m, *3-16 m*), *Turbo smaragdus* (0-44 m, *0-3 m*).
Bivalves: *Austrovenus stutchburyi* (0-20 m, *intertidal*), *Macomona liliana* (0-16 m, *0-7 m*), *Musculista senhousia* (0-5 m, *0-5 m*), *Nucula hartvigiana* (0-25 m, *0-17 m*), *Ruditapes largillierti* (0-32 m, *0-8 m*), *Theora lubrica* (0-55 m, *0-27 m*).
Echinoid: *Evechinus chloroticus* (0-5 m+, *0-5 m+*).

DOMINANTLY SUBTIDAL

Chitons: *Leptochiton inquinatus* (0-34 m, *0-34 m*), *Rhyssoplax stangeri* (1-21 m, *1-21 m*).
Gastropods: *Antisolarium egenum* (2-38 m, *7-24 m*), *Epitonium minora* (1-40 m, *1-38 m*), *Epitonium tenellum* (0-7 m, *3-5 m*), *Maoricolpus roseus* (0-32 m, *0-13 m*), *Micrelenchus rufozonus* (2-34 m, *2-27 m*), *Pupa kirki* (1-55 m, *1-55 m*), *Sigapatella novaezelandiae* (0-55 m, *0-55 m*), *Sinuginella pygmaea* (0-55 m, *1-31 m*), *Xymene plebeius* (0-28 m, *0-21 m*), *Zeacolpus pagoda* (1-42 m, *1-29 m*), *Zegalerus tenuis* (0-44 m, *1-22 m*).
Bivalves: *Arthritica bifurca* (2-38 m, *2-38 m*), *Atrina zelandica* (1-42 m, *3-38 m*), *Chlamys zelandiae* (0-55 m, *2-6 m*), *Corbula zelandica* (0-44 m, *0-32 m*), *Dosina zelandica* (0-38 m, *1-32 m*), *Dosinia maoriana* (3-38 m, *3-31 m*), *Dosinia subrosea* (1-15 m, *1-13 m*), *Felaniella zelandica* (0-55 m, *0-29 m*), *Gari convexa* (2-7 m, *2-7 m*), *Gari lineolata* (1-38 m, *1-22 m*), *Gari stangeri* (1-31 m, *1-15 m*), *Glycymeris modesta* (1-40 m, *2-27 m*), *Hunkydora australica novozelandica* (0-44 m, *2-32 m*), *Leionucula strangei* (6-35 m, *6-35 m*), *Leptomya retiaria* (0-34 m, *0-20 m*), *Limatula maoria* (2-44 m, *2-14 m*), *Melliteryx parva* (2-44 m, *2-12 m*), *Moerella huttoni* (2-38 m, *2-29 m*), *Myadora striata* (0-32 m, *1-18 m*), *Notocallista multistriata* (0-44 m, *0-44 m*), *Nucula nitidula* (0-44 m, *0-29 m*), *Pecten novaezealandiae* (0-44 m, *3-38 m*), *Pleuromeris zelandica* (0-48 m, *0-29 m*), *Scalpomactra scalpellum* (1-44 m, *1-29 m*), *Talabrica bellula* (2-34 m, *2-32 m*), *Tawera spissa* (0-44 m, *1-30 m*), *Tellinota edgari* (0-20 m, *1-20 m*), *Tucetona laticostata* (0-38 m, *2-21 m*), *Venericardia purpurata* (0-55 m, *2-34 m*), *Zenatia acinaces* (0-38 m, *0-38 m*).
Echinoid: *Echinocardium cordatum* (0-35 m, *4-35 m*).
Corals: *Culicia rubeola* (1-55 m, *1-15 m*), *Monomyces rubrum* (0-31 m, *0-31 m*).
Rhodolith alga: (0-30 m, *2-11 m*).

RESTRICTED TO DEEPER WATER (Fig. 3)
Gastropods: *Liracraea odhneri* (>18 m, none live), *Microvoluta marginata* (8-40 m, *8-38 m*), *Poirieria zelandica* (>13 m, none live), *Rhizorus nesentus* (4-40 m, *28-38 m*).
Bivalves: *Anisodonta alata* (>11 m, none live), *Crenella radians* (>31 m, none live), *Cuspidaria trailli* (>20 m, *>38 m*), *Neilo australis* (>11 m, *>15 m*), *Pratulum pulchellum* (2-44 m, *15-44 m*), *Saccella bellula* (7-55 m, *27-48 m*), *Serratina charlottae* (>13 m, *>13 m*).

Scaphopods: *Antalis nana* (>16 m, *>17 m*), *Cadulus teliger* (>21 m, none live).
Corals: *Kionotrochus suteri* (>38 m, none live), *Sphenotrochus ralphae* (>10 m, *>27 m*).

TAXONOMIC NOTES

Subspecies of Liratilia conquista *(Suter, 1907)*
Powell (1979) and Spencer and Willan (1996) recognise a northern subspecies (*L. c. conquista*) and a southern subspecies *L. conquista angulata* (Suter, 1908). The latter is distinguished by its more angulated whorls resulting from the differing strengths of spiral cords. In a dredge sample from 7 m off Motuarohia Island in the Bay of Islands there are shells identical in character to both these subspecies (AK93678, 93688). Forms identifiable as both subspecies are also present in a sample from 92 m off the Three Kings Islands (AK19151). We conclude that these two morphotypes are not geographically separate subspecies and at most should be considered separate forms.

Subspecies of Neoguraleus lyallensis *(Murdoch, 1905)*
Powell (1979) and Spencer and Willan (1996) recognise a southern nominate subspecies (*N. l. lyallensis*) and a northern subspecies *N. lyallensis tenebrosus* (Powell, 1926). The latter is distinguished by being more broadly ovate, less ornamented and having a dark, leaden grey colour compared with a yellowish-brown colour of the nominate subspecies. Study of shell populations from the Bay of Islands and elsewhere in northern New Zealand (e.g. AK84599, 100725) shows that shape, extent of axials and colour is highly variable within populations, with specimens referable to both subspecies present together. We suspect that some of the lighter-coloured nominate subspecies are faded leaden grey *N. l. tenebrosus.* We conclude that these two morphotypes are not geographically separate subspecies and at most should be considered separate forms, and thus we would refer to all as *N. lyallensis.*

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APPENDIX 1. Species list, depth ranges and qualitative assessment of abundance of molluscs from the Bay of Islands compiled from subtidal dredge, snorkel, and intertidal surveys with additional records of rarer species supplied by colleagues, shell collectors and records of Auckland War Memorial Museum holdings. This list does not include unshelled cephalopods. Also listed are some other marine invertebrates and rhodoliths (calcareous red algae) that have hard shell remains (e.g. barnacles, echinoids, corals and brachiopods), as their depth ranges are also of potential value to paleoecologists. Taxonomy follows Spencer and Willan (1996) with a few modifications (*Atrina, Herpetopoma, Scutus*) following Marshall (1998 and pers. comm.). Qualitative measures of abundance within depth ranges: a = living, A = living (averaging >1 per 50 litres of total sediment sampled), d = dead, D = dead (averaging >1 per 50 litres of total sediment sampled), (a) or (d) = observed living or dead during a scuba or snorkel dive, 1970s-1990s. x = collected previously from the Bay of Islands, depth not recorded.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Number of stations	8	78	59	32	18	9	9	11	5
POLYPLACOPHORA									
Acanthochitona rubiginosa	.	.	a	.	.	.	.	.	.
Acanthochitona violacea	a	a	d	.	.	.	.	.	.
Acanthochitona zelandica	A	A	A	.	.	.	.	.	.
Callochiton aff. *oligosulculatus*	a	.	.	.	.	.	.	.	.
Chiton glaucus	A	a	.	.	.	.	.	.	.
Cryptoconchus porosus	a	.	.	.	.	.	.	.	.
Eudoxochiton nobilis	a	.	.	.	.	.	.	.	.
Ischnochiton luteoroseus	.	a	.	.	.	.	.	.	.
Ischnochiton maorianus	A	A	a	a	.	.	.	.	.
Ischnochiton aff. *maorianus*	x	.	.	.	.	.	.	.	.
Leptochiton inquinatus	A	A	A	A	a	a	a	a	.
Leptochiton sp.	.	.	a	.	.	.	.	.	.
Lorica haurakiensis	.	.	a	.	.	.	.	.	.
Onithochiton neglectus	a	a	a	.	a	.	.	.	.
Plaxiphora obtecta	a	.	.	.	.	.	.	.	.
Pseudotonicia cuneata	.	a	A	.	.	.	.	.	.
Rhyssoplax canaliculata	.	.	a	.	.	.	.	.	.
Rhyssoplax stangeri	.	A	A	a	.	a	.	.	.
Rhyssoplax sp.	x	.	.	.	.	.	.	.	.
Sypharochiton pelliserpentis	A	d	a	.	.	.	.	.	.
GASTROPODA									
Acteon craticulatus	.	.	.	.	.	.	.	d	.
Acteon milleri	.	.	.	.	.	.	.	a	.
Adelphotectonica reevei	.	.	.	.	.	.	.	a	.
Agatha georgiana	.	D	d	d	.	d	.	d	d
Alcithoe arabica	.	d	.	.	.	.	.	.	d
Alcithoe haurakiensis	.	.	.	.	.	.	.	.	d
Alipta crenistria	.	.	.	d	.	.	.	.	.
Alloiodoris lanuginata	x	.	.	.	.	.	.	.	.
Alvania pingue	.	.	.	.	.	.	.	.	a
Alvania pinguoides	x	.	.	.	.	.	.	.	.
Amalda australis	d	a	a	a	d	.	.	d	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Amalda mucronata	.	d	d	d	d	.	a	d	.
Amalda northlandica	.	.	.	d	.	.	.	.	.
Amalda novaezelandiae	A	A	A	A	A	A	A	A	d
Amphibola crenata	a	d	d	.	d	.	.	.	.
Amphithalamus falsestea	.	d	d	d	.	.	.	.	.
Amphithalamus semen	.	d	.	.	.	.	.	.	.
Amphithalamus ornatus	a	.	.	.	.	.	.	.	.
Amphithalmus latisulcus	.	.	.	d	.	.	.	.	.
Anabathron elongatus	.	.	.	d	.	.	.	.	.
Anabathron excelsus	.	d	.	.	.	.	.	.	.
Anabathron hedleyi	a	.	.	.	.	.	.	.	.
Anabathron ovatus	.	d	d	d	.	.	.	.	.
Anabathron rugulosus	x	.	.	.	.	.	.	.	.
Antimelatoma buchanani maorum	.	d	.	a	a	.	.	d	.
Antisolarium egenum	.	D	A	A	d	A	D	d	.
Austrodrillia rawitiensis	.	d	.	.	.	.	.	.	.
Aoteatilia larochei	.	.	d	d	d	.	.	.	.
Aphelodoris luctuosa	.	(a)	.	.	.	.	.	.	.
Aplysia juliana	.	(a)	.	.	.	.	.	.	.
Asteracmea suteri	.	a	d	.	d	d	.	.	.
Astraea heliotropium	.	a	d	.	.	.	.	d	.
Atalacmea fragilis	a	.	.	.	.	.	.	.	.
Attenuata manawatawhia	.	.	.	.	.	.	.	.	d
Austrodiaphana manganuica	.	d	.	.	.	.	.	.	.
Austrodrillia secunda	.	.	.	.	.	.	.	.	d
Austrofusus glans	d	.	d	.	.	d	.	a	d
Austromitra rubiginosa	.	a	d	d	d	d	d	.	d
Awanuia dilatata	.	d	.	.	.	.	.	.	.
Babakina caprinsulensis	.	.	(a)	.	.	.	.	.	.
Berghia australis	a	.	.	.	.	.	.	.	.
Berthella ornata	x	.	.	.	.	.	.	.	.
Berthellina citrina	.	a	.	.	.	.	.	.	.
Besla vaga	.	.	.	.	.	.	.	.	a
Bouchetriphora pallida	.	d	d	d	.	.	a	.	.
Brookula indigens	.	d	d	.	.	.	.	.	.
Brookula polypleura	.	d	d	.	.	.	.	.	.
Buccinulum linea	a	a	a	.	.	.	.	d	.
Buccinulum pallidum powelli	.	.	(a)	.	.	.	.	.	.
Buccinulum robustum	d	.	a	.	.	.	.	.	.
Buccinulum vittatum	a	d	d	.	.	.	.	.	.
Bulla angasi	d	.	(d)	.	.	.	.	.	.
Bulla quoyii	A	A	a	d	.	.	.	.	.
Bullina lineata	.	.	(a)	.	.	.	.	d	.
Cabestana spengleri	.	.	.	.	d	.	.	.	.
Caecum digitulum	.	d	d	.	.	.	.	.	.
Calliostoma pellucidum	d	.	.	.	.	.	.	.	.
Calliostoma punctulatum	.	.	.	d	d	.	.	d	.
Calliostoma tigris	.	.	.	.	.	.	d	.	.
Cantharidella tesselata	d	d	.	.	.	.	.	.	.
Cantharidus opalus	d	d	d	.	.	.	.	.	.
Cantharidus purpureus	a	D	D	d	d	.	.	d	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Casmaria perryi	.	(a)	.	.	.	.	.	.	.
Cellana ornata	A	.	d	.	.	d	d	.	.
Cellana radians	A	.	.	.	d	.	.	d	.
Cellana stellifera	a	(a)	.	d	.	.	.	.	.
Ceratosoma amoena	.	(a)	.	.	.	.	.	.	.
Charonia lampas	.	(a)	.	.	.	.	.	.	.
Chemnitzia kingi	.	a	.	.	.	.	.	.	.
Chemnitzia spp.	.	d	d	d	.	d	.	.	.
Chromodoris aureomarginata	.	(a)	.	.	.	.	.	.	.
Cirsonella aff. *paradoxa*	.	d	.	.	.	.	.	.	.
Cirsotrema zelebori	.	a	a	d	.	a	d	.	.
Coluzea spiralis	x	.	.	.	.	.	.	.	.
Cominella adspersa	A	A	A	a	a	.	.	.	.
Cominella glandiformis	d	D	d	.	.	.	.	.	.
Cominella maculosa	a	A	.	a	.	.	.	.	.
Cominella quoyana	A	A	A	A	A	a	d	a	.
Cominella virgata	a	a	d	.	.	.	.	.	.
Cookia sulcata	a	a	a	.	.	.	d	.	.
Crassitoniella carinata	.	.	d	d	.	.	.	.	.
Crepidula costata	A	D	D	D	D	D	D	D	d
Crepidula monoxyla	A	a	d	.	.	d	.	.	.
Crepidula profunda	.	(a)	.	.	.	.	.	.	.
Crosseola cuvieriana	.	d	.	.	.	.	.	.	.
Crosseola vesca	.	d	d	.	.	.	.	.	.
Cumia reticulata	.	.	.	(a)	.	.	.	.	.
Curveulima aupouria	a	.	.	.	.	.	.	.	.
Cylichna thetidis	.	d	a	d	a	a	a	a	d
Cylichnina opima	.	.	.	.	.	.	.	.	d
Cymatium exaratum exaratum	.	(a)	.	.	.	.	.	.	.
Cymatium parthenopeum	.	a	.	.	.	.	.	.	.
Daphnella cancellata	.	d	d	D	d	.	.	.	d
Dendrodoris denisoni	.	(a)	.	.	.	.	.	.	.
Dermatobranchus pulcherrimus	.	a	.	a	.	.	.	.	.
Dicathais orbita	a	d	.	.	.	.	.	d	.
Dicavolinia longirostris	.	.	.	.	.	.	.	d	.
Diloma arida	d	d	.	.	.	.	.	.	.
Diloma bicanaliculata	a	d	.	.	.	.	.	.	.
Diloma coracina	a	d	.	.	.	.	.	.	.
Diloma nigerrima	d	d	.	.	.	.	.	.	.
Diloma subrostrata	A	D	d	.	d	.	.	.	.
Diloma zelandica	d	d	.	.	.	.	.	.	.
Dolabrifera brazieri	.	a	.	.	.	.	.	.	.
Doriopsis flabellifera	a	.	.	.	.	.	.	.	.
Eatoniella albocolumella	.	d	.	.	.	.	.	.	.
Eatoniella delli	.	d	.	.	.	.	.	.	.
Eatoniella flammulata	a	.	.	d	.	.	.	.	.
Eatoniella fossa	.	.	.	d	.	.	.	.	.
Eatoniella limbata	.	d	d	d	.	.	.	.	.
Eatoniella lutea	.	d	.	.	.	.	.	.	.
Eatoniella mortoni	.	d	.	.	.	.	.	.	.
Eatoniella notalabia	.	d	.	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Eatoniella notata	.	.	d	.	.	.	.	.	.
Eatoniella olivacea	.	d	d	.	.	.	.	.	.
Eatoniella puniceomacer	.	d	d	d	.	.	.	.	.
Eatoniella roseocincta	.	a	d	d	.	.	.	.	.
Eatoniella roseola	.	.	d	d	.	.	.	.	.
Eatoniella tenella	.	.	.	d	.	.	.	.	.
Eatonina atomaria	d	.	.	.	.	.	.	.	.
Eatonina micans	.	d	d	.	.	.	.	.	.
Eatonina subflavescens	.	.	d	.	.	.	.	.	.
Emarginula striatula	.	D	d	d	d	d	.	d	d
Epitonium bucknilli	.	d	.	.	.	.	.	.	.
Epitonium jukesianum	.	d	.	d	.	d	.	.	.
Epitonium minora	.	A	A	A	D	a	d	a	.
Epitonium tenellum	d	A	d	.	.	.	.	.	.
Eulima perspicua	d	.	.	.	.	.	.	.	.
Eulimella levilirata	.	.	d	d	.	.	.	.	.
Fictonoba carnosa carnosa	.	(a)	.	.	.	.	.	.	.
Fictonoba rufolactea	d	.	.	.	.	.	.	.	.
Fossarina rimata	a	.	d	.	.	.	.	.	.
Fusceulima mangonuica	.	.	.	d	.	.	.	.	.
Fusinus genticus	.	.	.	.	.	.	(a)	.	.
Gadinia conica	d	.	.	.	.	.	.	.	.
Glaphyrina caudata	.	.	.	.	.	.	.	d	.
Goniodoris n.sp.	.	(a)	.	.	.	.	.	.	.
Granosolarium aspersum	.	.	.	.	.	.	.	.	d
Gumina dolichostoma	.	d	.	d	.	.	.	.	.
Haliotis australis	d	a	d	.	.	.	.	.	.
Haliotis iris	d	d	.	.	.	.	.	.	.
Haliotis virginea crispata	a	d	.	.	.	.	.	.	.
Haminoea zelandiae	d	d	.	.	.	.	.	.	.
Haustrum haustorium	a	.	.	.	.	.	.	.	.
Herpetopoma alacerrima	.	.	.	.	.	d	.	.	.
Herpetopoma bella	a	.	.	.	.	.	.	.	.
Herpetopoma benthicola	.	.	.	d	.	.	.	.	.
Herpetopoma larochei	.	d	d	d	.	.	.	.	.
Heterocithara mediocris	x	.	.	.	.	.	.	.	.
Haloginella mustelina	d	.	.	.	.	.	.	.	.
Homalopoma fluctuata	.	a	d	d	d	.	.	.	.
Homalopoma imperforata	.	.	.	.	.	.	.	.	d
Hypermastus bulbula	.	a	.	.	.	.	.	.	.
Incisura lytteltonensis	a	.	.	.	.	.	.	.	.
Incisura rosea	.	d	d	.	.	.	.	.	.
Janthina exigua	d	.	.	.	.	.	.	.	.
Janthina janthina	d	.	.	.	.	.	.	.	.
Kagomea ficula	.	d	d	d	.	.	.	.	.
Lamellaria ?ophione	.	.	a	.	.	.	.	.	.
Lamellaria ophione	.	.	d	.	d	d	.	.	.
Larochea miranda	.	d	d	.	.	.	.	.	.
Larochella alta	.	d	.	.	.	.	.	.	.
Lepsiella scobina	A	d	.	.	.	.	.	.	.
Leuconopsis obsoleta	a	.	.	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Limulatys reliquus	.	.	(a)	.	.	d	.	.	.
Linopyrga rugata	.	d	d	d	.	.	.	.	.
Liracraea odhneri odhneri	.	.	.	.	d	.	d	d	d
Liracraea sp.	.	.	.	.	.	d	.	.	.
Liratilia conquisita conquisita	.	d	d	d	.	.	.	.	.
Liratilia elegantula	.	d	.	.	.	.	.	.	.
Liratilia eremita	.	d	.	.	.	.	.	.	.
Liratilia subnodosa	d	.	.	.	.	.	.	.	.
Lodderena formosa	.	d	d	.	.	.	.	.	.
Lodderia iota	.	d	.	.	.	.	.	.	.
Lucerapex angustatus	.	.	d	.	a	a	d	d	.
Macrozafra nodicincta	.	.	.	.	.	.	.	.	d
Macrozafra subabnormis	d	.	.	.	.	.	.	.	d
Maoricolpus roseus	a	A	A	A	d	.	.	d	.
Marinula filholi	a	.	.	.	.	.	.	.	.
Melagraphia aethiops	A	d	.	d	.	.	.	.	.
Melanella sp.	.	d	d	.	.	.	.	.	.
Mendax stiria	d	.	.	.	.	.	.	.	.
Mendax ?trizonalis	.	d	d	d	.	.	.	.	.
Merelina compacta	.	(d)	.	.	.	.	.	.	.
Merelina coronata	.	(d)	.	.	.	.	.	.	.
Merelina crosseaformis	.	.	d	.	.	.	.	.	.
Merelina lyalliana	d	.	.	.	.	.	.	.	.
Merelina superba	.	.	d	.	.	.	.	.	.
Merelina taupoensis	d	.	.	.	.	.	.	.	.
Metaxia duplicarinata	.	d	.	.	.	.	.	.	.
Metaxia exaltata	.	.	d	.	.	.	.	.	.
Micrelenchus dilatatus	a	.	.	.	.	.	.	.	.
Micrelenchus huttonii	a	.	.	.	.	.	.	.	.
Micrelenchus rufozonus	.	A	A	D	a	d	A	d	.
Micrelenchus sanguineus	.	d	d	a	.	.	.	.	.
Micrelenchus tenebrosus	A	D	d	d	.	.	.	.	.
Microdryas striatus	.	d	.	.	.	.	.	.	.
Microtralia occidentalis	a	.	.	.	.	.	.	.	.
Microvoluta marginata	.	.	a	d	.	A	.	a	.
Mitra carbonaria	.	(a)	.	.	.	.	.	.	.
Modelia granosa	.	d	d	d	.	.	.	.	.
Monophorus fascelina	.	.	d	.	.	.	.	.	.
Morula palmeri	.	.	.	.	(a)	.	.	.	.
Munditia delicatula	x	.	.	.	.	.	.	.	.
Munditia serrata	.	d	.	.	.	.	.	.	.
Munditia tryphenensis	.	d	d	d	.	.	.	.	d
Murdochella levifoliata	.	.	.	.	.	.	.	.	d
Murexul mariae	.	.	.	.	d	.	.	d	.
Murexul octogonus	d	A	a	.	d	d	.	.	.
Nassarius aoteanus	.	.	.	.	.	.	(d)	.	.
Nassarius spiratus	d	.	.	.	.	.	.	.	.
Natica lemniscata	d	.	.	.	.	.	.	.	.
Natica migratoria	d	.	.	.	.	.	.	.	.
Neoguraleus amoenus	.	d	D	d	d	D	d	d	d
Neoguraleus aff. *benthicola*	.	.	.	.	d	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Neoguraleus interruptus	.	d	d	d	.	.	.	.	.
Neoguraleus lyallensis	a	A	A	.	d	d	.	d	.
Neoguraleus murdochi	A	A	D	D	D	D	D	.	.
Neoguraleus sinclairi	.	.	.	d	.	.	.	.	.
Nepotilla nitidula	.	.	d	.	.	.	.	.	.
Nerita atramentosa	a	.	.	.	.	.	.	.	.
Nodilittorina cincta	a	.	.	.	.	.	.	.	.
Nodilittorina antipodum	A	d	.	.	.	.	.	.	.
Notoacmea elongata	a	d	.	d	.	.	.	.	.
Notoacmea helmsi	a	d	d	.	d	.	d	d	.
Notoacmea parviconoidea	a	.	d	.	.	.	.	d	.
Notoacmea pileopsis pileopsis	a	.	.	.	.	.	.	.	.
Notoacmea scopulina	d	.	.	.	.	.	.	.	.
Notoacmea subtilis	.	A	a	d	.	.	.	.	.
Notocrater craticulata?	.	.	.	.	.	d	.	.	.
Nototriphora aupouria	x	.	.	.	.	.	.	.	d
Novastoa lamellosa	a	d	.	.	.	.	.	.	.
Nozeba emarginata	.	d	d	d	.	.	.	d	.
Obexomia denselirata	.	d	d	.	.	.	.	.	.
Odostomia chordata	.	d	d	.	.	.	.	.	.
Odostomia incidata	.	d	d	d	.	.	.	d	d
Odostomia pudica	x	.	.	.	.	.	.	.	.
Odostomia vestalis	.	.	d	.	.	.	.	.	.
Odostomia sp.	.	.	.	d	.	.	.	.	.
Onchidella nigricans	A	.	.	.	.	.	.	.	.
Onoba candidissima	x	.	.	.	.	.	.	.	.
Ophicardelus costellaris	d	d	d	.	.	.	.	.	.
Orbitestella parva	a	.	.	.	.	.	.	.	.
Orbitestella toreuma	d	d	.	.	.	.	.	.	.
Paratrophon quoyi	a	.	.	.	.	.	.	.	.
Patelloida corticata	a	.	.	d	.	.	.	d	.
Paxula paxillus	x	.	.	.	.	.	.	.	.
Peculator hedleyi	.	a	d	d	.	.	.	d	.
Penion cuverianus	.	.	(d)	.	.	.	.	.	.
Penion sulcatus	.	d	d	d	a	.	.	.	.
Pervicacia tristis	a	A	a	a	.	d	.	.	.
Phenacovolva wakayamaensis	.	.	(a)	.	.	.	.	.	.
Phenatoma rosea	.	.	a	a	d	d	.	.	.
Phenatoma zealandica	.	.	.	a	d	.	.	.	.
Phidiana milleri	a	.	.	.	.	.	.	.	.
Philine auriformis	.	D	D	d	D	d	d	.	d
Philine powelli	.	.	.	.	.	.	.	d	d
Philine sp.	.	a	a	a	a	a	.	a	.
Philinopsis taronga	.	a	a	a	a	.	.	.	.
Philippia lutea	d	.	.	.	.	.	.	.	.
Phyllocoma speciosa virginalis	.	.	d	.	.	.	.	.	.
Pisinna olivacea impressa	.	d	d	d	.	.	.	.	.
Pisinna manawatawhia	.	d	d	d	.	.	.	.	.
Pisinna rekohuana lactorubra	.	.	.	.	a	.	.	.	.
Pisinna rekohuana rekohuana	.	d	d	.	.	.	.	.	.
Pisinna semiplicata	.	d	d	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Pisinna semisulcata	.	.	d	d	.	d	d	D	.
Pisinna zosterophila	.	d	d	d	.	.	.	.	.
Pleurobranchaea maculata	.	(a)	.	.	.	.	.	.	.
Poirieria zelandica	.	.	.	d	d	.	.	d	.
Polinices simiae	d	.	.	.	.	.	.	.	.
Polinices tawhitirahia	x	.	(a)	.	.	.	.	.	.
Potamopyrgus estuarinus	A	.	.	.	.	.	.	.	.
Powellisetia crassilabrum	.	d	.	.	.	.	.	.	.
Powellisetia subtenuis	.	d	.	.	.	.	.	d	.
Proxiuber australe	.	a	a	d	d	.	.	d	.
Proxiuber hulmei	.	.	.	.	d	.	.	.	.
Pseudotorinia amoena	.	.	.	.	.	.	.	.	d
Pseudovermis hancocki	x	.	.	.	.	.	.	.	.
Psilaxis radiatus	d	.	.	.	.	.	.	.	.
Prototyphis eos	a	.	.	.	.	.	.	.	.
Pupa kirki	d	A	A	A	a	A	A	A	a
Pusillina finlayi	x	.	.	.	.	.	.	.	.
Pusillina hamiltoni	d	.	d	.	.	.	.	.	.
Pusillina semireticulata	.	.	.	.	.	.	.	d	.
Pyramidelloides pagoda	d	.	.	.	.	.	.	.	.
Radiacmea inconspicua	a	.	.	.	.	.	.	.	.
Ranella australasia	d	(a)	.	.	.	.	.	.	.
Retusa oruaensis	.	d	.	.	.	.	.	.	.
Rhizorus nesentus	.	d	.	.	d	.	a	A	.
Risellopsis varia	a	d	d	.	.	.	.	.	.
Rissoella elongatospira	a	.	.	.	.	.	.	.	.
Rissoella micra	.	d	d	.	.	.	.	.	.
Rissoina achatina	.	a	d	a	.	.	d	d	.
Rissoina anguina	.	.	d	.	.	.	.	.	.
Rissoina aupouria	.	.	a	.	.	.	.	.	.
Rissoina chathamensis	d	A	D	.	a	.	.	.	.
Rissoina fictor	.	d	d	.	.	.	.	d	.
Rissoina fucosa	.	D	d	d	a	.	d	.	.
Rissoina manawatawhia	.	.	d	.	.	a	.	d	d
Rissoina zonata	.	(d)	.	.	.	.	.	.	.
Rostanga muscula	a	.	.	.	.	.	.	.	.
Runcina katipoides	.	a	.	.	.	.	.	.	.
Sagenotriphora ampulla	.	d	d	.	.	.	.	.	.
Sassia palmeri	.	.	.	.	(d)	.	.	.	.
Sassia parkinsonia	d	.	(a)	.	.	.	.	.	.
Scrinium neozelanicum	.	.	.	d	.	.	.	.	.
Scrupus hyalinus	x	.	.	.	.	.	.	.	.
Scutus breviculus	a	.	.	.	.	.	.	.	.
Seila terebelloides	.	a	a	d	.	.	.	.	.
Semicassis labiata	x	.	.	.	.	.	.	.	.
Semicassis pyrum	d	.	.	.	.	.	.	d	.
Semicassis royana	.	.	.	.	.	(a)	.	.	.
Serpulorbis aotearoicus	a	.	.	.	.	.	.	.	.
Serpulorbis sp.	.	D	.	.	.	.	.	.	.
Sigapatella novaezelandiae	a	A	D	A	A	D	D	A	A
Sinezona brevis	d	.	.	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Sinezona levigata	.	(a)	.	.	.	.	.	.	.
Sinuginella larochei	.	d	d	d	.	.	.	d	.
Sinuginella pygmaea	d	A	A	D	d	d	a	D	d
Sinuginella tryphenensis	.	a	d	d	.	.	.	D	D
Siphonaria australis	A	d	d	.	d	d	.	.	.
Spectamen plicatulum	.	.	d	.	.	.	.	d	D
Spectamen tryphenense	.	.	.	.	.	.	d	.	.
Spectamen verum	.	.	.	.	.	.	.	.	d
Splendrillia aoteana	.	a	a	.	d	.	.	d	.
Splendrillia sp.	d	d	.	d	d	d	.	.	.
Stephopoma rosea	.	d	d	.	.	.	.	.	.
Struthiolaria papulosa	d	d	D	a	a	d	d	a	d
Struthiolaria vermis	d	D	a	A	a	D	.	.	.
Syrnola crawfordi	d	.	.	.	.	.	.	.	.
Syrnola lurida	.	.	d	d	.	d	.	.	.
Syrnola menda	.	.	.	.	.	.	.	a	d
Tanea zelandica	d	a	a	a	d	a	.	d	.
Taranis aff. *nexilis bicarinata*	.	.	.	.	.	.	.	a	d
Taron dubius	a	d	d	a	.	.	.	.	.
Tenagodus weldii	.	.	d	.	.	.	.	.	.
Terebra circumcincta	.	(a)	.	.	.	.	.	.	.
Terelimella larochei	.	d	.	.	.	.	.	.	.
Thoristella carmesina	d	d	D	d	.	d	a	.	.
Thoristella oppressa	.	d	.	.	.	.	a	.	.
Tomopleura albula	.	A	a	a	a	.	d	d	d
Tonna cerevisina	d	d	.	.	.	.	.	d	d
Trichosirius inornatus	d	d	a	d	.	d	.	d	.
Tritonia incerta	.	.	(a)	.	.	.	.	.	.
Trivia merces	d	d	a	.	.	d	.	.	.
Trochus tiaratus	a	A	a	a	a	d	.	d	.
Trochus viridus	d	d	d	d	.	.	.	d	.
Tubbreva exigua	x	.	.	.	.	.	.	.	.
Tubbreva minutula	.	d	d	d	.	.	.	.	.
Tugali elegans	a	d	.	d	.	d	.	.	.
Tugali suteri	d	d	d	d	d	d	d	d	.
Turbo smaragdus	A	a	d	.	.	.	d	.	d
Tutufa bufo		d	.	.	(a)	.	.	.	.
Uberella barrierensis	.	.	d	.	.	.	.	d	d
Uberella vitrea	.	.	.	.	.	.	.	.	d
Umbraculum umbraculum	d	.	.	.	.	.	.	.	a
Veprecula cooperi	.	.	.	.	.	.	.	.	d
Volutomitra obscura	.	.	(a)	.	.	.	.	.	.
Volvarinella amoena	.	.	.	.	.	.	.	d	d
Volvarinella cairoma	a	d	d	d	.	.	.	.	d
Volvarinella subfusula	.	.	.	.	.	.	.	.	D
Williamia radiata nutata	.	.	d	.	.	.	.	.	.
Xenophora neozelanica	x	.	.	.	.	.	.	.	.
Xymene ambiguus	d	D	D	d	d	d	.	d	.
Xymene huttoni	.	.	.	d	a	.	.	.	.
Xymene plebeius	A	A	D	a	D	a	d	.	.
Xymene pusillus	.	a	d	d	d	d	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Xymene traversi	d	d	a	d	.	.	.	.	.
Zaclys sarissa	.	.	d	.	.	.	.	.	.
Zalipais lissa	x	.	.	.	.	.	.	.	.
Zeacolpus pagoda	d	A	A	A	D	A	A	D	d
Zeacolpus vittatus	.	d	d	a	D	a	.	a	.
Zeacumantus lutulentus	a	d	.	.	.	.	.	.	.
Zeacumantus subcarinatus	A	D	d	.	.	.	.	.	.
Zebittium exile	d	D	a	d	d	.	.	.	d
Zegalerus tenuis	d	A	A	A	D	A	D	D	D
Zelippistes benhami	.	d	d	.	.	.	d	.	.
Zemitrella attenuata	.	.	.	d	.	.	.	.	.
Zemitrella choava	.	d	d	.	.	.	.	.	.
Zemitrella daemona	.	.	.	.	.	.	a	.	.
Zemitrella fallax	.	d	.	.	.	.	.	d	.
Zemitrella pseudomarginata	.	.	.	.	.	.	a	.	.
Zemitrella cf. *sericea*	.	.	.	.	.	.	.	d	.
Zemitrella turgida	x	.	.	.	.	.	.	.	.
Zeradina odhneri	.	.	.	.	.	.	.	.	d
Zeradina ovata	.	.	.	.	.	.	.	.	d
Zeradina producta	.	.	.	.	.	.	.	.	d
Zerotula ammonitoides	.	d	.	d	.	.	.	.	.
BIVALVIA									
Acar sandersonae	d	.	d	.	.	.	d	d	.
Acar sociella	.	d	d	d	.	d	d	.	D
Anisodonta alata alata	.	.	.	d	d	d	.	d	d
Anomia trigonopsis	d	D	d	D	d	.	.	.	.
Arthritica bifurca	.	A	a	A	.	.	.	a	.
Atrina zelandica	d	A	a	D	a	d	A	A	d
Austroneaera finlayi	.	d	.	.	.	.	.	.	d
Austrovenus stutchburyi	A	D	d	.	D	.	.	.	.
Bankia sp.	d	.	.	.	.	.	.	.	.
Barbatia novaezelandiae	a	a	d	d	d	.	d	d	d
Barnea similis	d	d	.	.	.	.	.	.	.
Bassina yatei	d	d	a	a	.	.	.	.	.
Benthocardiella obliquata	.	d	.	.	.	.	.	.	.
Borniola reniformis	.	d	a	.	.	.	a	d	d
Cardita aoteana	d	d	d	d	.	.	.	d	d
Cardita brookesi	a	.	.	d	.	.	d	d	.
Carditella delli	.	.	.	.	.	.	.	.	d
Chlamys gemmulata	.	.	d	.	.	.	d	.	.
Chlamys zelandiae	d	A	a	D	D	D	D	D	D
Condylocardia crassicosta	.	d	d	.	.	.	.	.	.
Condylocuna concentrica	.	d	d	.	.	.	.	.	.
Corbula zelandica	A	A	A	A	A	A	D	A	d
Cosa serratocostata	.	d	d	d	.	.	.	d	.
Crassostrea gigas	A	d	d	d	.	.	.	.	.
Crenella radians	.	.	.	.	.	.	.	d	d
Cuspidaria trailli	.	.	.	.	.	D	.	A	A
Cuspidaria wellmani	.	.	.	.	.	.	.	.	d
Cyclomactra ovata	d	A	.	.	.	.	.	.	.
Cyclopecten mestayerae	.	.	d	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Cyclopecten sp.	.	d	.	.	.	.	.	.	.
Diplodonta globus	.	.	.	d	.	.	.	d	d
Diplodonta striatula	d	a	.	.	.	.	.	.	.
Divaricella huttoniana	d	D	d	a	d	d	d	a	D
Divarilima sydneyensis	d	d	d	d	.	d	.	.	.
Dosina zelandica	d	A	A	D	D	d	d	d	d
Dosinia anus	d	.	.	.	.	.	.	.	.
Dosinia greyi	.	a	a	A	a	.	.	a	.
Dosinia lambata	d	A	A	A	A	d	a	a	.
Dosinia maoriana	d	a	A	a	A	d	d	a	.
Dosinia subrosea	d	A	A	a	.	.	.	.	.
Elliptotellina urinatoria	.	.	d	.	.	.	.	.	.
Felaniella zelandica	A	A	A	A	D	A	A	d	d
Gari convexa	d	A	a	.	.	.	.	.	.
Gari lineolata	d	A	A	A	a	a	D	d	.
Gari stangeri	d	A	A	A	d	d	D	d	.
Glycymeris modesta	d	A	A	A	D	D	A	D	.
Gonimyrtea concinna	.	a	a	.	.	d	.	a	d
Haliris setosa	.	.	.	.	.	.	.	.	d
Hamacuna aupouria	.	.	d	d	.	.	.	.	.
Hiatella arctica	d	d	a	d	d	d	d	d	d
Hunkydora australica novozelandica	d	A	A	A	A	a	d	a	d
Irus reflexus	d	d	.	.	.	.	.	.	.
Kidderia costata	.	(a)	.	.	.	.	.	.	.
Lasaea hinemoa	a	.	d	.	.	.	.	.	.
Lasaea maoria	a	.	.	.	.	.	.	.	.
Leionucula strangei	.	.	a	.	A	a	D	A	.
Leptomya retiaria	a	A	A	A	A	D	d	d	.
Limaria orientalis	a	A	A	a	.	d	.	.	.
Limatula maoria	d	A	a	a	d	D	d	d	D
Macomona liliana	A	A	a	d	d	.	.	.	.
Mactra murchisoni	d	.	.	.	.	.	.	.	.
Maorimactra ordinaria	d	a	a	d	.	d	D	.	.
Melliteryx parva	.	A	d	A	.	.	.	.	d
Mesopeplum convexum	.	d	.	.	.	d	d	D	.
Modiolarca impacta	a	d	.	d	D	d	d	d	.
Modiolus areolatus	d	d	a	d	.	d	.	.	.
Moerella huttoni	.	a	a	A	d	.	A	d	.
Montacuta semiradiata	.	.	a	a	a	.	.	.	.
Musculista senhousia	a	A	.	.	.	.	.	.	.
Myadora antipodum	.	a	a	a	.	A	d	a	d
Myadora boltoni	.	a	a	d	.	.	.	.	.
Myadora novaezelandiae	.	.	.	a	.	A	.	.	d
Myadora striata	d	A	A	A	a	d	D	d	.
Myadora subrostrata	.	d	d	a	D	d	d	d	.
Myllita stowei	.	d	d	d	d	d	.	d	.
Myllitella vivens	.	d	d	.	.	.	.	.	.
Myochama tasmanica	.	.	.	.	.	.	.	d	d
Mysella ?alpha	.	.	d	.	.	.	.	.	.
Mysella aupouria	.	.	.	d	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Mysella larochei	.	.	.	.	.	.	.	d	d
Mysella tellinula	.	.	d	.	.	.	.	.	.
Mytilus edulis galloprovincialis	.	d	.	.	.	.	d	D	.
Neilo australis	.	.	.	a	D	d	d	A	D
Neolepton antipodum	.	.	d	d	.	.	.	.	d
Notocallista multistriata	a	A	d	A	A	a	A	A	a
Nucinella maoriana	.	.	.	.	.	.	.	.	d
Nucula certisinus	.	.	.	.	.	.	.	.	d
Nucula hartvigiana	A	A	A	d	A	d	.	.	.
Nucula nitidula	a	A	A	A	A	A	A	D	d
Ostrea chilensis	d	D	d	D	D	.	.	d	.
Oxyperas elongata	.	d	d	a	.	.	d	.	.
Panopea zelandica	d	.	.	.	.	.	.	.	.
Paphies australis	a	a	d	.	d	.	.	.	.
Paphies subtriangulata	d	d	.	.	.	.	.	.	.
Parvithracia suteri	x	.	.	.	.	.	.	.	.
Pecten novaezealandiae	d	A	a	D	a	d	D	a	d
Periploma angasi	.	.	d	.	.	.	.	.	.
Perna canaliculus	a	a	.	.	.	.	.	.	.
Peronaea gaimardi	d	.	.	.	.	.	.	.	.
Philobrya acutangulata	.	d	d	d	.	.	.	.	d
Philobrya aff. *acutangula*	.	.	a	.	.	.	.	.	.
Philobrya cf. *modiolus*	.	.	d	.	.	.	.	.	.
Philobrya munita	.	a	.	.	.	.	d	.	.
Philobrya aff. *pinctada*	.	.	d	.	.	.	.	.	.
Pleuromeris latiuscula	.	a	.	a	.	.	.	.	.
Pleuromeris paucicostata	.	d	a	a	.	d	a	D	d
Pleuromeris zelandica	a	A	A	A	A	A	A	D	D
Pleuromeris sp.	.	.	d	.	.	.	.	.	.
Pododesmus zelandicus	.	.	.	.	.	.	.	.	d
Poroleda lanceolata	.	.	.	.	.	.	.	d	d
Pratulum pulchellum	d	D	d	A	A	a	A	A	A
Prototheca crassicosta	d	.	.	.	.	.	.	.	.
Pseudoarcopagia disculus	d	d	a	d	.	.	.	.	.
Ruditapes largillierti	a	A	A	d	d	.	.	d	.
Saccella bellula	.	.	d	.	d	d	A	A	A
Saccostrea cucullata	A	d	.	.	.	.	.	d	.
Scalpomactra scalpellum	.	A	D	A	a	A	A	D	d
Scintilla stevensoni	d	.	.	.	.	.	.	.	.
Scintillona zelandica	.	a	d	a	.	.	.	.	.
Serratina charlottae	.	.	.	a	a	d	a	a	A
Solemya parkinsoni	.	a	.	.	.	.	.	a	.
Soletellina nitida	d	a	.	d	.	.	.	.	.
Talabrica bellula	.	A	a	.	.	.	d	a	.
Tawera spissa	d	A	A	A	A	A	A	D	d
Tellinota edgari	d	A	A	A	A	.	.	.	.
Theora lubrica	a	A	A	A	A	D	A	d	d
Thracia vegrandis	.	.	.	.	.	.	d	.	.
Trichomusculus barbatus	.	d	a	d	.	.	D	.	.
Tucetona laticostata	d	A	A	a	d	A	d	D	.
Varinucula gallinacea	.	a	d	a	.	.	.	.	d

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Venericardia purpurata	d	A	A	A	A	D	A	A	D
Volupicuna compressidens	.	.	.	.	.	.	a	.	d
Volupicuna manawatawhia	.	.	.	.	.	.	.	.	d
Volupicuna mayi	.	.	.	a	.	.	.	.	.
Volupicuna waikukuensis	x	.	.	.	.	.	.	.	.
Xenostrobus pulex	A	d	.	d	d	.	.	.	.
Xenostrobus securis	.	d	.	.	.	.	.	.	.
Zelithophaga truncata	d	d	.	.	.	.	.	.	.
Zenatia acinaces	a	A	a	A	A	d	d	A	.
SCAPHOPODA									
Antalis nana	.	.	.	.	a	.	.	a	d
Cadulus teliger	.	.	.	.	.	d	d	d	d
CEPHALOPODA									
Spirula spirula	d	.	.	.	.	.	.	.	.
BARNACLES									
Balanus decorus	.	d	.	.	d	.	.	.	.
Balanus trigonus	d	A	d	d	d	.	.	.	.
Balanus vestitutus	.	d	d	d	d	.	D	D	.
Chamaesipho brunnea	A	d	.	.	.	.	.	.	.
Chamaesipho columna	A	d	.	.	.	.	.	.	.
Elminius modestus	A	d	.	.	.	.	.	.	.
Epopella plicata	A	d	.	.	.	.	.	.	.
BRYOZOA									
Otionella sp.	.	d	.	.	.	.	A	A	d
ECHINOIDS									
Apatopygus recens	.	.	a	.	.	a	.	.	.
Brissus gigas	.	.	(a)	.	.	.	.	.	.
Centrostephanus rodgersii	.	(a)	.	.	.	.	.	.	.
Clypeaster australasiae	.	.	.	.	(a)	.	.	.	.
Echinocardium cordatum	d	A	A	A	A	a	d	A	.
Evechinus chloroticus	A	a	d	d	d	d	d	d	.
Fellaster zelandiae	d	d	d	.	.	.	.	.	.
Holopneustes inflatus	a	(a)	.	.	.	.	.	.	.
Peronella hinemoa	.	.	.	.	.	.	.	.	d
Pseudoboleta indiana	.	.	.	.	(a)	.	.	.	.
Tripneustes gratilla	.	(a)	.	.	.	.	.	.	.
CORALS									
Caryophyllia sp.	.	.	.	.	.	.	.	.	d
Culicia rubeola	.	A	d	a	d	d	D	d	d
Hoplansia duotrix	x	.	.	.	.	.	.	.	.
Kionotrochus suteri	.	.	.	.	.	.	d	d	D
Monomyces rubrum	a	.	d	d	d	A	D	A	d
Sphenotrochus ralphae	.	.	d	.	.	.	a	d	.
Tethocyathus cylindraceus	.	.	.	.	.	.	.	.	d
BRACHIOPODS									
Calloria inconspicua	d	.	a	a	.	d	a	a	.
Calloria variegata	.	.	.	d	.	.	.	.	.
Terebratella haurakiensis	.	.	.	.	.	.	.	d	.
RHODOLITH ALGAE	d	A	A	A	d	D	D	.	.

SIX NEW FOSSIL BIVALVES FROM THE EARLY MIOCENE OF AUCKLAND AND NORTHLAND, NEW ZEALAND

MICHAEL K. EAGLE

Abstract. Six new fossil bivalve species are described from the Early Miocene of Auckland and Northland. All specimens were collected within the Waitakere, Waitemata, and Parengarenga Groups of the Akarana Supergroup.Two bathyal species, *Bentharca waitakarensis* n. sp. and *Euciroa (Euciroa) maoriana* n. sp., are from the Manukau Subgroup, Nihotupu Formation, Parekura and Maori Bay Members respectively. Four inner- middle-shelf species, *Paphies otaiana* n. sp., *Chama (Chama) hunua* n. sp., and *Austrovenus northlandica* n. sp. are from the Kawau Subgroup, Tipakuri Sandstone Member, and *Donax (Paradonax) parengarengaensis* n. sp. was collected from the Paratoetoe Formation, Te Pokere Mudstone Member. The genera *Bentharca* and *Donax* are new additions to the New Zealand fossil molluscan fauna. *Paphies otaiana* appears to be a phylogenetic precursor to *Paphies porrecta*, *P. donacina* and *P. subtriangulata*. *Austrovenus northlandica*, and *Chama (Chama) hunua* are the first species of these genera to be described from the Miocene of New Zealand.

KEYWORDS: Bivalvia; *Bentharca*; *Euciroa*; *Paphies*; *Chama*; *Austrovenus*; *Donax*; new taxa; Early Miocene; Waitakere Group; Waitemata Group; Parengarenga Group.

INTRODUCTION

Many of the Early Miocene sediments of Auckland and Northland are fossiliferous. They are diverse in both lithology and fossil content. Palaeobathymetry, palaeoclimate, volcanism and marine transgressions, largely influenced deposition and faunas during the Otaian and Altonian (Burdigalian). This paper describes new fossil taxa collected on field trips to Hays Stream (Hunua Ranges), Shaw Road quarry (Waitakere Ranges), and Maori Bay (Motutara), in the Auckland area, and to Paratoetoe Point (Parengarenga Harbour) in Northland (Fig. 1).

Fossil record numbers (e.g. R12/f72) are those of the Geological Society of New Zealand Fossil Record File. Specimens are held in the marine invertebrate collections, Auckland War Memorial Museum (prefix AK); the palaeontological collections, Geology Department, University of Auckland (L); and the author's collection (ME). Palaeoecological and palaeoenvironmental assessments are based on the known ecology of genera living today and of modern species most closely related to these fossils. Systematics and nomenclature follows Cox *et al.* (1969), and Beu *et al.* (1990).

PREVIOUS WORK

Hays Stream, Hunua Ranges, south-east Auckland

Eagle & Hayward (1992) reviewed past studies at this site, recording 131 macrofossil and 97 foraminiferal taxa from Hays Stream, adding fish, barnacles and polychaetes to previous faunal

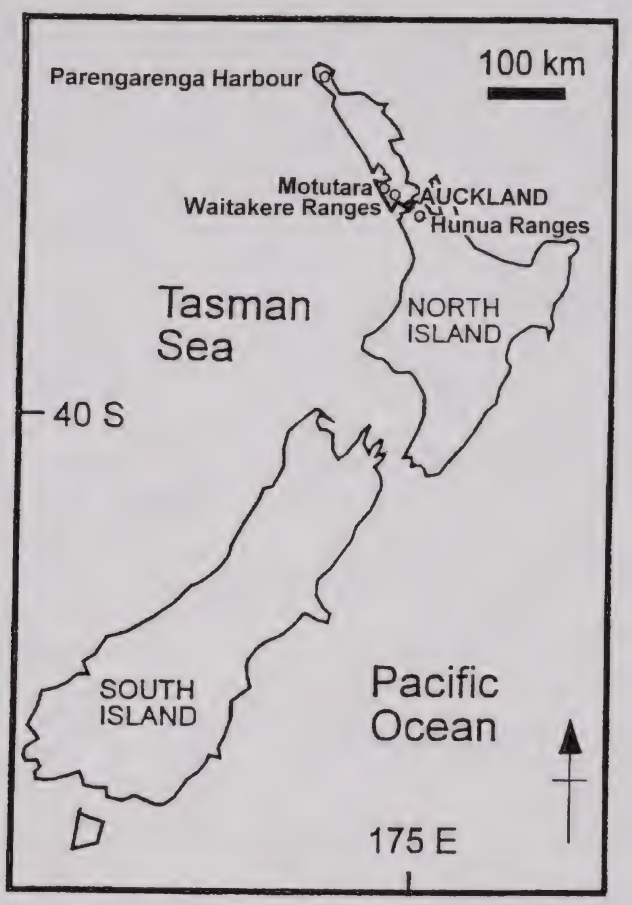


Fig. 1. Map of New Zealand showing northern North Island fossil localities of specimens collected and described in this paper.

lists. Fossils from the Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984; Eagle 1992a) from fossil locality R12/f72 (1:50 000 NZMS 260 grid reference R12/863566), northern Hunua Ranges, were collected by Hayward, Hollis, de Carteret, and Eagle in January 1992 and by Hayward and Eagle in February 1992. Macrofossil and microfossil biostratigraphy confirm an Early Miocene, Otaian (Burdigalian) age (Eagle & Hayward 1992). For a geological map of the area see fig. 1 of Eagle & Hayward (1992).

Shaw Road quarry, Waitakere Ranges

Macrofossils were first discovered in the 1930s at the Shaw Road quarry, Oratia, in the Waitakere Ranges, Auckland (Fig. 2). Collections made by Hulme and Schofield, New Zealand Geological Survey, during mapping and sampling in 1961, were placed in the Geological Survey collections, Lower Hutt. These collections were used by Hayward (1979) in his discussion of deep Miocene faunas from the region. Microfossil evidence (Hayward 1983) suggests that these middle Altonian faunas are the youngest known marine sediments in the eastern Waitakere Ranges. Fossils were collected by Eagle in March 1989 and by Grant-Mackie and Eagle in February 1990.

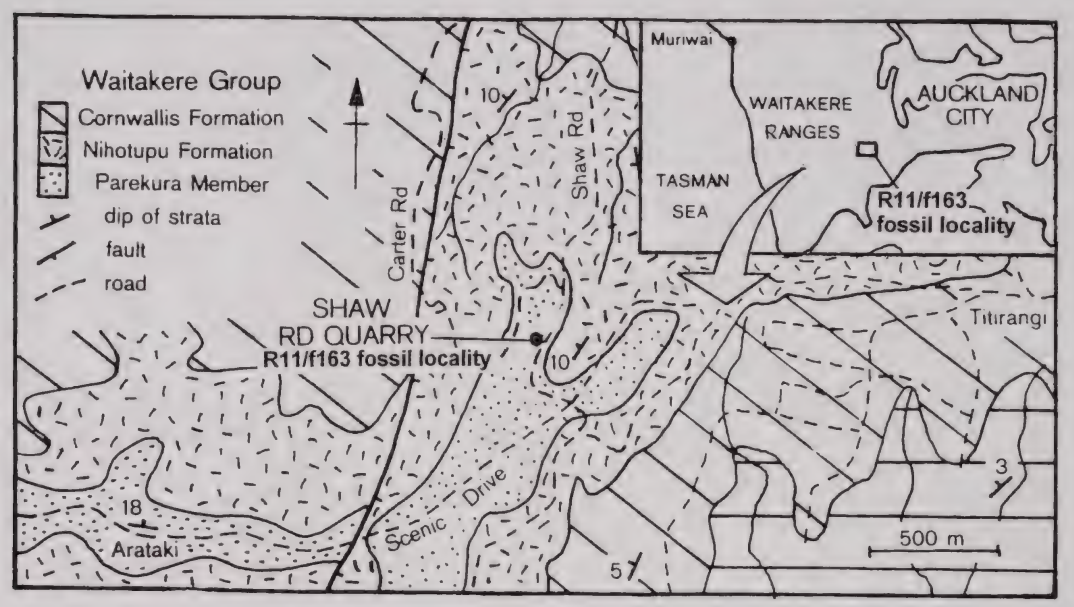


Fig. 2. Schematic geological map showing location of the Shaw Road quarry fossil locality, Waitakere Ranges (after Hayward 1979).

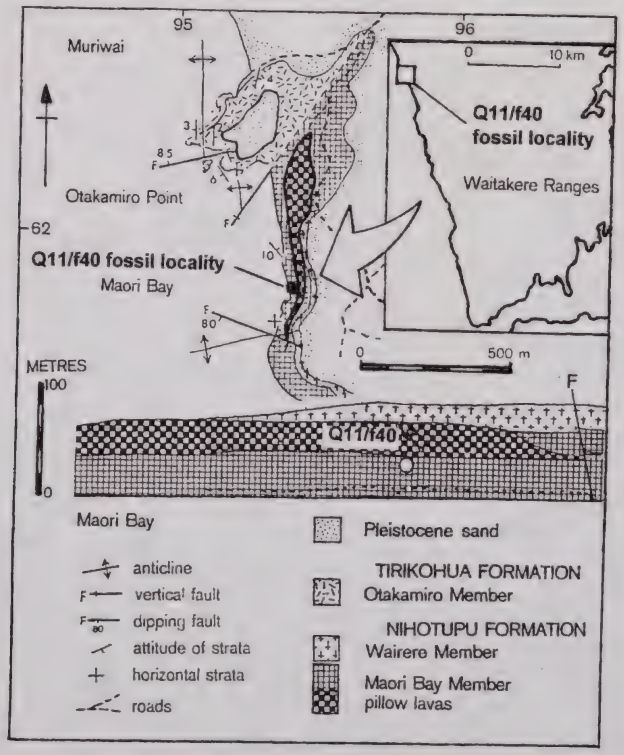


Fig. 3. Schematic geological map showing location of the south Maori Bay fossil locality, Motutara, north-west Auckland (after Hayward 1979).

South Maori Bay, Motutara, north-west Auckland

Powell (1935) described specimens collected from sparsely fossiliferous tuffs underlying pillow-lavas in the coastal cliffs at the south end of Maori Bay (Fig. 3). Bandy *et al.* (1970) K/Ar-dated the andesitic pillar lavas (16.8 Ma), used in turn to date a planktonic foraminiferal datum level within the upper part of the Early Miocene. Hayward (1979) mapped and named the strata here and further along the south coast as well as describing new fossil taxa (Hayward 1981). Eagle (1992b; 1999) described a new deep-water chemoautotrophic lucinid bivalve and a sea star from Motutara. Fossils from the Waitakere Group, Manukau Subgroup, Nihotupu Formation, Maori Bay Member (Hayward 1976a) from fossil locality Q11/f40 (1:50 000 NZMS 260 grid reference Q11/378840) were collected by Eagle in July 1990. Microfossil evidence confirms a mid-Altonian (Burdigalian) age (Hayward & Buzas 1979).

North shore, Parengarenga Harbour

Kear & Hay (1961), Leitch (1966, 1970) and Brook (1989) mapped the northern Parengarenga and North Cape area. Ballance (1974) outlined the principal palaeogeographic features, including Early Miocene sedimentary basins in Auckland and Northland. Wakefield (1976) named new lithographic units and fossil tax from both Otaian and Altonian sequences outcropping on the north shore of Parengarenga Harbour. Grenfell (1984) described fish otiliths collected from Parengarenga Harbour Early Miocene fossil localities. Fossils from the Parengarenga Group, Paratoetoe Formation (Leitch 1970), Altonian fossil locality NO2/f231 (1:50 000 NZMS 260 grid reference NO2/055444) (Fig. 4), were collected by Stace, Morley, Hayward and Eagle in October 1992.

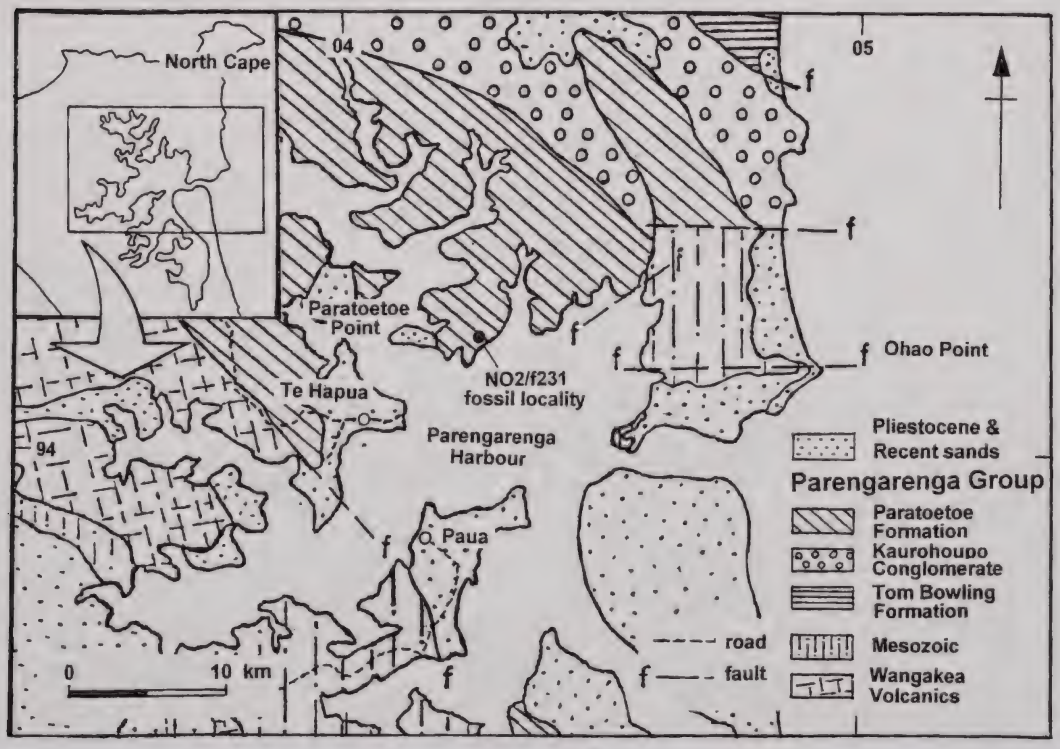


Fig. 4. Schematic geological map showing location of the Paratoetoe Formation fossil locality, north shore, Parengarenga Harbour (after Wakefield 1976).

GEOLOGICAL SETTING

REGIONAL

Early Miocene rocks occur throughout Auckland and Northland. They are characterised by warm water biotas poorly preserved in weathered outcrops of great lateral variation related to contemporous volcanism and tectonism (Beu *et al.* 1990). Weathered outcrops include various lithologies such as pillow lavas, volcanic breccia and tuff beds. The Late Oligocene and Early Miocene rocks of northern New Zealand were reviewed by Ballance *et al.* (1978) who proposed the Akarana Supergroup with seven groups, three of which are relevant to this paper—Waitemata Group (Ballance 1976), Waitakere Group (Hayward 1976b), and Parengarenga Group (Wakefield 1976). A deep marine Waitemata Basin covered the Auckland region in Early Miocene times. This basin was large and was flanked east and west by volcanic arcs which produced the lavas and volcaniclastic sediments of the Waitemata Group and Waitakere Group (forming the present-day Waitakere Ranges). Sediments of the Parengarenga Group were deposited in outer-shelf to upper bathyal zones as submarine canyon-fan down-slope sediments within a regional back-arc basin (Ballance 1974).

SPECIFIC SITES

Hunua Road cutting, Hays Stream, Hunua Ranges, south-east Auckland

Eagle & Hayward (1992) reviewed the geology of this site. The Hunua Road cutting fossil fauna is preserved as decalcified to good-quality specimens in a bed of muddy, shelly conglomerate. The particular fossil bed in which specimens were collected is 3.5 m above the cutting on the first bend in the Hunua Road east of the road bridge, at the start of the gorge. The fossil bed appears to have been mixed preburial during downslope transport in a sub-aqueous gravity flow. Occassional fossils are found within ripped-up clasts which are deposited irregularly throughout the unit.

Shaw Road quarry, Waitakere Ranges (Fig. 2)

The Shaw Road quarry consists of coarse volcaniclastic lithofacies of the Parekura Member, Nihotupu Formation, Waitakere Group (Hayward 1976b, 1976c). The Parekura Member consists predominantly of massive beds of pebbly volcanic breccia-conglomerate with a discontinuous layer (<1 m thick) of interbedded fine volcaniclastic grit, sandstone, and siltstone that constitutes, in part, a bathyal flysch (Sporli 1983). These accumulated seafloor sediments suggest a transported filling of an earlier fossil submarine canyon or distributory channel (Hayward 1979). The Shaw Road quarry is "perhaps the deepest-water molluscan faunule yet recorded from New Zealand" (Beu *et al.* 1990), containing only a few taxa, all of which are diagnostically bathyal. Foraminfera indicate deposition in 1000-2000 m (Hayward & Buzas 1979).

South Maori Bay, Motutara, north-west Auckland (Fig. 3)

The Maori Bay early Miocene post-depositional upthrown fault bock is part of a major group of four that are separated by three northeast-striking faults along the Muriwai-Te Waharoa (Motutara) coastline. The 1.2 km Maori Bay block is folded into a broad anticline with an ENE plunging axis (Hayward 1976a; 1983). The location of the Maori Bay Member type section is coincidental with the new fossil species type locality. Holocene and early Miocene sands immediately overlie pillow lava high in the stratigraphic sequence of south Maori Bay. The Maori Bay Member (Hayward 1979), south Maori Bay, is located within the Nihotupu

Formation, Waitakere Group, Manukau Subgroup (Hayward 1979). The lithofacies exposed in the coastal sequence at south Maori Bay consists of muddy volcarenite (containing coarse pumice lapilli), that are well-bedded and hydrothermally altered. The unit contains few taxa, all of which indicate a bathyal depth (Hayward 1979, Beu *et al.* 1990).

North shore, Parengarenga Harbour (Fig. 4)
The Parengarenga Group, Paratoetoe Formation (Leitch 1970), on the north shore of Parengarenga Harbour, is part of an extensive submarine canyon-fan complex deposited in the Late Otaian—Early Altonian as part of the Parengarenga Group. The Paratoetoe Formation contains a distinctive fossiliferous unit that is a massive, blue-grey fine to medium sandy-siltstone flysch unit 20 m thick that forms high, eroded cliff sections on the north and south sides of Paratoetoe Penninsula. The mudstone unit is moderately consolidated and shows few diagenetic features. The most extensive section exposed at Te Pokere, north-west Paratoetoe Point, has steeply eroded slopes 45 m high. The section possesses an abundant, diverse, well-preserved marine fossil fauna. The mudstone unit is also exposed and more readily accessible along the north Parengarenga Harbour shoreline, just south of Waipatukohu Stream to Paratoetoe Point. Fresh exposures are reduced in this section by weathering along tensional fault systems, creating massive debris slopes littered with exhumed Early Miocene Mollusca (Wakefield 1976, Beu *et al.* 1990).

Although massive, the mudstone contains occasional concentrations (some showing faint parallel laminae) of molluscan shell material, and vague shell lineations that parallel indistinct bedding planes. Calcareous fossils retain their original mineralogy, wood fragments are carbonised, and vertebral bone fragments have been partially silicified. Bioturbation is excessive, with individual ichnofauna barely discernable. Irregular tubular and ellipsoidal calcitic concretions occur erratically in cliff sections, eventually weathering out, falling down-slope, finally concentrating on the shore platform. On the shore platform between Waipatukohu and Waiomoko Streams, large cylindrical concentrations have developed around simple, tubular, 25 mm diameter ichnofossils, approximately normal to the indistinct bedding. Several ferruginous cemented, irregularly shaped, rough mounds, 0.3-0.5 m high and 0.2-0.4 m wide, are also to be found on the shore platform, eroded from strata above. They apparently developed by the preferential weathering of entwined ichnofossils from within the massive mudstone cliffs.

SYSTEMATICS

CLASS:	BIVALVIA Linnaeus, 1758
SUBCLASS:	PTERIOMORPHIA Beurlen, 1944
ORDER:	ARCOIDEA Lamarck, 1809
SUPERFAMILY:	ARCACEA Lamarck, 1809
FAMILY:	ARCIDAE Lamarck, 1809
SUBFAMILY:	ANADARINAE Reinhart, 1935
GENUS:	*Bentharca* Verrill & Bush, 1898
Type species:	*Macrodon asperula* Dall, 1881 (by original designation). Recent, Gulf of Mexico.

Diagnosis: Shell equivalve, compressed, inequilateral, umbones in anterior quarter; outline subtrapezoidal; anterior greatly restricted; posterior margin broadly rounded, expanded; anterior margin indented by byssal sinus; dorsal margin long and straight; ligament restricted to posterior area; hinge plate narrow; teeth in two series separated by edentulous gap; sculpture of faint radial striae; adductor muscle scars indistinct, unequal (Cox *et al.*1969; Knudsen 1970).

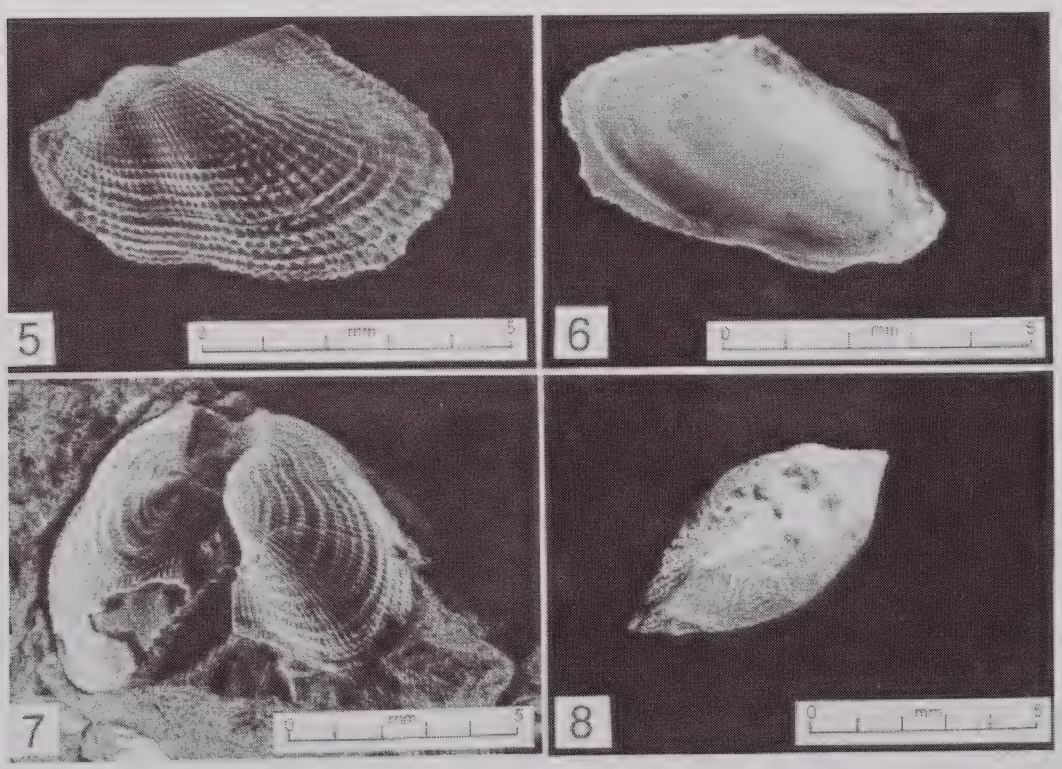
Bentharca waitakarensis n. sp. (Figs 5-8, 9, 12)

MATERIAL
Holotype: L3833, adult specimen exterior (Fig. 5), interior (Fig. 6). Paratypes: L3834, block with both valves complete (Fig.7). L3835, two blocks with single right valve on one and the external cast on the other. L3836, block with single left valve. L3837, partially broken left valve. L3838, broken left valve with articulated steinkern and broken left valve. AK72301, single right valve. ME9001, articulated specimen with conjoined valves (Fig. 8).

TYPE LOCALITY
Specimens are from the Waitakere Group, Manukau Subgroup, Nihotupu Formation, Parekura Member (Hayward 1976b), fossil localities R11/f160 and R11/f163, Shaw Road quarry, Oratia, Waitakere Ranges, West Auckland (Fig. 2).

AGE
Middle Altonian Stage (Burdigalian), based on foraminiferal faunas (Hayward 1983) and correlated molluscan faunas collected from other dated localities within the Waitakere Group.

DISTRIBUTION
Known only from the Shaw Road quarry.



Figs 5-8. *Bentharca waitakerensis* n. sp. 5. Holotype L3833, left valve exterior. 6. Holotype L3833, left valve internal. 7. Paratype L3834, oblique dorsal view of articulated shell. 8. Paratype ME9001, conjoined valves.

ETYMOLOGY
Named after the Waitakere Ranges.

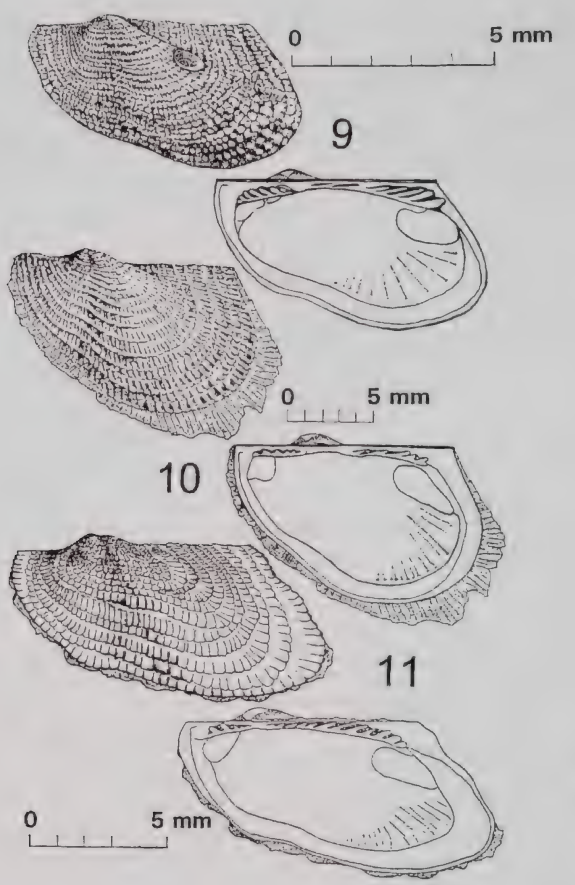
DESCRIPTION
Small, thin-shelled, equivalve, inequilateral. Shell outline obliquely subpyriform, dorsal extremities angular, umbone situated at about anterior third, beak broadly pointed, prosogyrous. Posterior and anterior margins subparallel, oblique, posterior about twice length of anterior margin. Anterior margin curves gently to form a shallow embayment in outline becoming the broadly convex sweep of ventral margin. Posteroventral margin narrowly rounded marking distal end of prominent postumbonal ridge. Inflation of anterior region causes shallow anteroventral sulcus forming marginal embayment corresponding to shallow gape in commissure plane in right valve. Shell sculpture strong, decussate, with radial and commarginal ridges. Ligament duplinvicular, elongate, very narrow. Hingeline straight, occupying 5/6 of shell length, with gently arched dental series consisting of small, oblique, subequal, short, smooth, undivided teeth, which converge ventrally and diminish in size medially. Anterior dental series slightly shorter, more irregularly shaped than posterior, both separated by a postumbonal edentulous gap less than half postumbonal hinge length. Posterior aductor muscle scar irregular with an anterodorsally directed linguoid projection. Anterior adductor muscle scar elevated, smooth, subquadrate, with no obvious growth marks. Interior ventral margin curves dorsally, uninterrupted and smooth. Meristics: Table 1 gives measurements of *Bentharca waitakarensis* n. sp.

Table 1. Measurements (mm) of *Bentharca waitakarensis* n. sp.

Specimen	Height	Length	Inflation	Post-umbonal length
holotype L3833	5.2	9.1	2.9	4.0
paratype L3834	4.8	8.1	2.3	3.9
paratype L3835	3.1	7.2	2.1	2.7
paratype L3836	3.2	7.0	2.3	3.0
paratype L3837	4.0	7.1	2.3	3.2
paratype L3838	4.1	7.9	2.3	3.2
paratype AK72301	4.1	7.6	2.4	3.0

REMARKS
The Shaw Road arcid has been variously allocated to *Notogrammatodon* (Hayward 1979) and the genus *Bathyarca* of which numerous species have been described from the Cenozoic fossil record. The genus *Bentharca* was originally created to separate the bathyal-abssyal Recent species *Bentharca asperula* (Dall, 1881) (Figs 10, 13) from other species of *Bathyarca*. Beu *et al.* (1990) tentatively included the new fossil species in *Bentharca*, an allocation consistent with morphologic characteristics and inferred depositional depth.

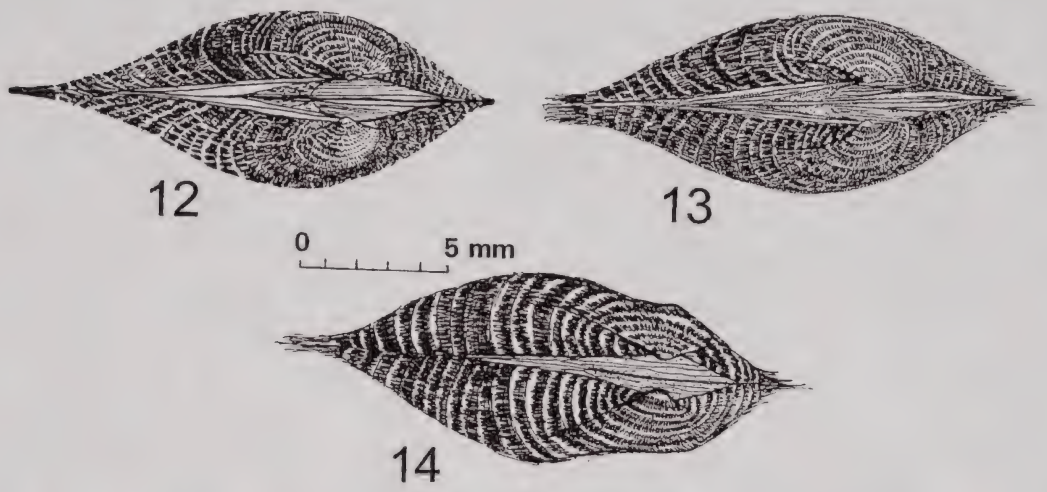
The early Miocene fossil is similar to *B. asperula* (Dall, 1881), *B. nodulosa* (Muller, 1776) (Figs 11, 14) and *B. xenophoricola* (Kuroda, 1968), in its small size and shell height, but it is more elongate and has a more reduced inflation in the posterior quadrant. Hinge lines of all four species are long and straight, that of *B. waitakerensis* having five almost horizontal posterior



Figs 9-11. Line drawings of *Bentharca* species showing shell outline, sculpturing and internal morphological features. 9. *Bentharca waitakerensis* n. sp. 10. *B. asperula* (after Cox *et al.* 1969). 11. *B. nodulosa* (after Knudsen 1970).

and eight anterior teeth, whereas *B. asperula* has only four posteriorly and six anteriorly. Knudsen (1967) studied shape variation in the shell of *B. asperula* and intraspecific variation in the position and number of hinge teeth. The degree of variation in *B. waitakerensis* is similar. Unlike comparable Recent species, *B. waitakerensis* lacks myophoric ridges or shelves, has a posterior adductor muscle scar that is more irregular in outline with an anterodorsally directed linguoid projection, and a subquarate anterior muscle scar that is more elevated, with no obvious growth tracks. The overall shape, dentition arrangement, differences in shell sculpture and internal muscle scars, all differentiate *B. waitakerensis* from other known bentharcids.

Bentharca is a suspension filter-feeder, byssally attached to a hard substrate. It dwells in areas of deep-flowing turbidity currents that convey suspended nutrient-rich organic material. Prehistoric turbidity currents that flowed through the Shaw Road submarine canyon sustained the benthic fauna with food then destroyed it by an inundation of volcanoclastic sediment. Associated macrofauna collected at the fossil locality (e.g. *Saccella motutarensis* Powell, 1935; *Vaginella aucklandica* Clarke, 1905; *Bathytoma mitchelsoni* Powell, 1935) have modern analogues



Figs 12-14. Line drawings of *Bentharca* species showing details of escutcheon, umbo and lunule. 12. *B. waitakerensis*. 13. *B. asperula*. 14. *B. nodulosa*.

in bathyal and abssyal assemblages. Some microfossils at the Shaw Road quarry site were probably displaced downslope by submarine mass debris flows (Ballance & Gregory 1991), as is apparent in adjacent localities (Hayward 1976c). Sufficient microfossil evidence is, however, associated with *B. waitakerensis* to suggest that the byssally-attached bivalve lived at 1000-2000 m (Hayward & Buzas 1979). Naticid and other borings are evident on several specimens, indicating benthic predation by carnivorous Mollusca.

The Shaw Road bathyal-abssyal zone possibly had temperatures of 4-10°C, consistent with the findings of Bruun (1956, 1957). A eurythermal-eurybathyal genus such as *Bentharca* could possibly cope with benthic temperature fluctuations during the gradual transformation from warmer Middle Altonian sea conditions to those of the present day. Distribution of Recent *Bentharca* indicates the genus has a temperature tolerance of 1.1-11.7°C; 75% of *B. asperula* are from water cooler than 4° with 50% of these living at abssyal depths below 3° (Knudsen 1967). Recent *B. asperula* occurs in the Atlantic Ocean, northern Indian Ocean, southeast Asian waters, north-west Pacific Ocean, the Tasman Sea and the Kermadec Trench, with a known depth of 430-3005 m (Knudsen 1970). Recent *B. nodulosa* and *B. xenophoricola* are temperate species. The close morphological similarily between *B. waitakerensis* and *B. asperula* suggests an ancestor-decendant relationship.

The deep-sea fauna is rich in archaic forms, and the cold bathyal-abssyal depths of the world's oceans have been a refuge for certain molluscs (Ekman 1953). The Arcidae is a conservative family as evidenced by its long and continuous fossil record extending back to the Triassic. General shell characteristics in the Arcoidea have remained stable over those hundreds of millions of years (Newell 1965). *Bentharca* is likely to have remained comparatively unchanged for so long because it persisted in the deep sea.

SUBCLASS:	HETERODONTA Neumayer, 1884
ORDER:	VENEROIDEA H. Adams & A. Adams, 1856
SUPERFAMILY:	MACTRACEA Lamark, 1809
FAMILY:	MESODESMATIDAE Gray, 1839

GENUS: *Paphies* Lesson, 1831. For diagnosis see Cox *et al.* (1969 and Beu & de Rooij-Schuiling (1982).

Type species: *Paphies roissyana* Lesson, 1830 (original designation; = *Mya australis* Gmelin, 1791). Recent, South Pacific.

Paphies otaiana n. sp. (Fig. 15)

MATERIAL

Holotype: AK72652, left valve (juvenile?) embedded in sandstone matrix; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting R12/f72.

AGE

Macrofossil and foraminiferal biostratigraphy confirm an early Miocene, Otaian (Burdigalian) age (Eagle & Hayward 1992).

ETYMOLOGY

Named for its Otaian age.

DESCRIPTION

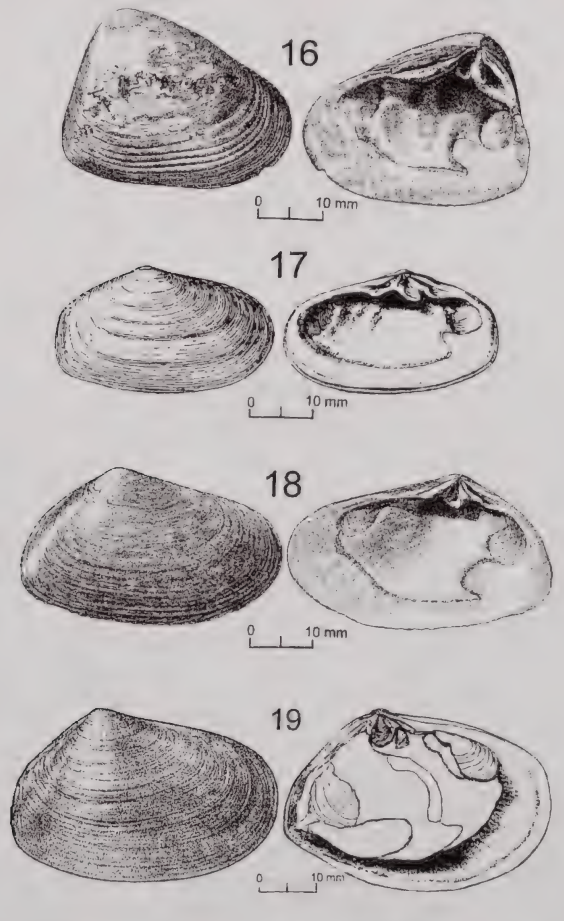
Shell small, solid, moderately thick, low, oval, strongly inequilateral, elongate, long. Anterior end rounded. Shell height 15.1 mm, length 23.8 mm, inflation 4.1 mm. Posterior end weakly convex, posterodorsal area convex. Umbo highest point on shell, beak at posterior third. Shell

Fig. 15. Lateral view of holotype of *Paphies otaiana* n. sp. (AK72652).

unsculptured with low, smooth, commarginal growth ridges prominent distally. Hinge line thick, narrow. Shell interior infilled by indurated sandstone matrix.

REMARKS

Four Recent species of *Paphies*, *P. australis* (Gmelin, 1791), *P. subtriangulata* (Wood, 1828), *P. donacina* (Spengler, 1793), and *P. ventricosa* (Gray, 1843), are common around mainland New Zealand, Chatham Island, and Auckland Island coastlines. A Chatham Island *Paphies* form living at Petre Bay, previously thought to be a living example of the Neogene fossil *P. porrecta* (Marwick, 1928), was synonomised by Smith *et al.* (1989) with *P. subtriangulata*. The known fossil record of *Paphies* is sparse. Pleistocene and Pliocene specimens have been collected at well-known Quaternary localities such as the Rangitikei Valley, Kai-iwi, Castlecliff (Wanganui Basin), and Titirangi in the Chatham Islands. One species, *Paphies anteaustralis* (Dell, 1950), has been described from the Miocene (Beu 1971). Cenozoic exposed sandy coast facies are rare and associated fossil faunas are correspondingly rare.



Figs 16-19. Line drawings of New Zealand fossil and Recent *Paphies* species. 16. *Paphies crassiformis* (from Beu *et al.* 1990). 17. *P. subtriangulata*. 18. *P. porrecta* (from Beu *et al.* 1990). 19. *P. ventricosa* (external view from Suter 1915).

The Cenozoic fossil record contains seven species: *P. anteaustralis* (Otaian), *P. australis* (Nukumaruan-Recent), *P. crassiformis* (Marshall & Murdoch, 1920) (Nukumaruan), *P. donacina* (Mangapanian-Recent), *P. porrecta* (Nukumaruan), *P. subtriangulata* (Haweran-Recent), and *P. ventricosa* (Castlecliffian-Recent) (Beu *et al.* 1990). Several fossil and Recent species are similar to *P. otaiana* n. sp., although because of hinge-line, overall shape, and comarginal growth variations, *P. anteaustralis* and *P. australis* are not. Most specimens of *P. crassiformis* (Fig. 16) are more triangular than *P. otaiana* and possess a very heavy hinge-line. Some of the forms of *P. crassiformis,* however, are not always so triangular, may have the posterior considerably longer than the anterior end, and may show more resemblance to the northern species *P. subtriangulata* (Fig. 17). Holocene *P. subtriangulata* from The Bluff, Ninety Mile Beach, and Recent specimens from Long Bay, Auckland, also have an excessively heavy hinge (Stace 1996). The northern and southern species *P. donacina,* which is morphologically similar to *P. subtriangulata*, is characterised by a subtriangular shape, a rather short anterior end and a less posterior beak than that of *P. subtriangulata* and a broad, expanded posterodorsal area. *P. otaiana* is not considered conspecific with *P. crassiformis*, *P. subtriangulata,* or *P. donacina* because of its more elongate, narrower overall shape, a more widely rounded anterior dorsal margin, a more weakly convex posterior end and a less angled posteroventral extremity. *P. otaiana* is similar to *P. porrecta* (Fig. 18) and *P. ventricosa* (Fig. 19) in morphology, but is more narrowly elongate, possesses a fuller and more rounded anterior dorsal margin that is not as truncated, has a weaker rounded ridge from umbo to ventral curve of anterior margin, is not as inflated, and has growth ridges parallel to ventral and dorsal margins. Of all New Zealand *Paphies* species, the extant *P. subtriangulata* is the most similar to *P. otaiana.*

The notion that *Paphies* may have migrated to New Zealand during the Pliocene (where they first appear in large numbers) is based on the proliferation of species with no known fossil progenitors. The discovery of a second *Paphies* species in the early Miocene suggests otherwise. *P. anteaustralis* and *P. otaiana* were either probable direct ancestors to *P. australis* and *P. subtriangulata-P. donacina* respectively, or ancestral to unknown *Paphies* forms that migrated away from the southern biotic province post-Otaian, only to return pre-Nukumaruan. Alternatively, *Paphies* progenitors may have existed, but have not been preserved or discovered. A lack of suitably preserved facies would explain the absence of pre-Neogene progenitors for *P. ventricosa* and *P. donacina.*

SUPERFAMILY: CHAMACEA Lamark, 1809
FAMILY: CHAMIDAE Lamark, 1809
GENUS: *Chama* Linnaeus, 1758
Type species: *Chama (Chama) lazarus* Children, 1823 (by subsquent designation). Recent. Australia, central Pacific, Phillipines, Indonesia, Malayasia, central Indian Ocean, California, Ecuador, Galapagos Islands.

Diagnosis: Shell small to large; variable sculpture, well developed, usually concentric, sometimes radial, or both; shell sessile at least temporarily; umbones prosogyrate; ligament and resilium external, situated in a deep groove; hinge usually with a minute or obsolete posterior lamina in fixed valve; one large cardinal tooth in either valve, two cardinals and weak laterals in some; adductor scars unequal; pedal scars minute and distant (Cox *et al.* 1969).

SUBGENUS: *Chama* Linnaeus, 1756

Diagnosis: Concentric ornamentation of distinctive flattened spines in irregular radial rows (Cox *et al.* 1969).

Chama (Chama) hunua n. sp. (Figs 20-23)

MATERIAL

Holotype: AK 72655, single right valve, umbone prosogyrate (Fig. 20). Paratypes: L3938 (Fig. 21), single right valve, internal; AK 72657 (Figs 22, 23), single left valve, umbone opistogyrate; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting.

DISTRIBUTION

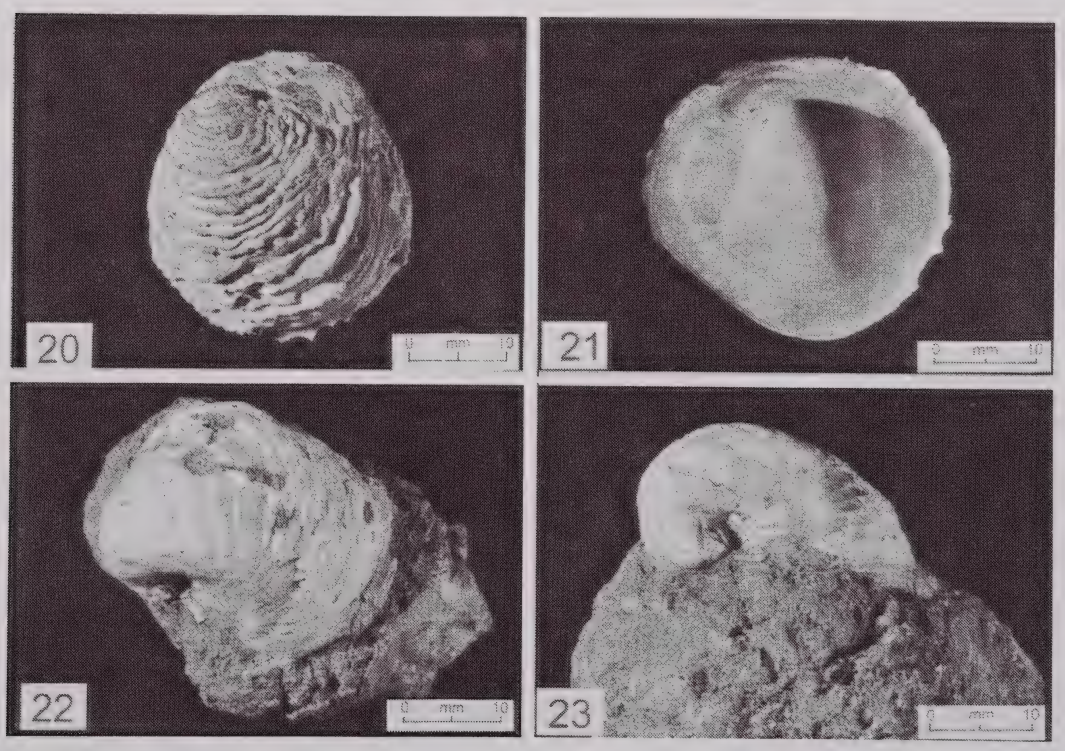
Known from Hays Stream (Northern Hunua Ranges), Waitakere Ranges, and Pakurangi Point (Kaipara Harbour) (Beu *et al.* 1990).

ETYMOLOGY

Named after the Hunua Ranges.

DESCRIPTION

Shell large for genus, length to 80 mm, greatly inflated, heavy, thick-walled, external layer prismatic in structure. Right valve free, subcircular, length greater than width, height 30-78 mm, length 30.2-80 mm, inflation 13.2-24.8 mm. Shell sculpture elaborate with commarginal



Figs 20-23. *Chama (Chama) hunua* n. sp. 20. Holotype AK72655, right valve lateral external view. 21. Holotype AK72655, right valve lateral internal view. 22. Paratype AK72657, left valve dorsal view showing ?predatory borings. 23. Paratype AK72657, left valve showing opistogyrate umbone.

rows of elevated, broad-frilled, thin, finely spinose growth ridges rather than distinct lamellae bearing fine radial grooves and ridges. Umbone prominent, dorsally elevated, strongly developed, spirally coiled, prosogyrate. Right hinge with prominent socket, upper side strongly, crudely rugose, situated on lower portion of plate. Cardinal tooth elongate, crude with narrow lower ridge that borders distal margin of deeply incised ligmental groove. Interior ventral margin smooth, aragonitic porcellaneous. Adductor muscle scars unequal, large, ovate, anterior smaller than posterior. Pallial line continuous. Shell interior surface roughened with short, irregularly meandering lines or grooves. Left valve sessile, height 36.1-81 mm, length 37-76.2 mm, inflation 27.9-51 mm. Umbone strongly inflated, opistogyrate; beak curled inward. Aperture subcircular, length greater than width. Hinge and valve internal surface not seen.

REMARKS

The New Zealand Pliocene species *Chama huttoni* (Hector, 1886) from Castlepoint (Nukumaruan) and another Cenozoic chamid, *C. pittensis* Marwick, 1928 (Waipipian) from Pitt Island, Chatham Islands, are the only named fossil species of this genus from New Zealand. Right valves of *Chama* species have been found at many early Miocene localities, among them Pakurangi Point, Clifden, and the Waitakere Ranges. Left *Chama* valves, such as those of *C. (Chama) hunua* are extremely uncommon. An undescribed, possibly new chamid found in early Eocene rocks of Mangaporapan age from the upper Waihao River, South Canterbury (Beu *et al.* 1990) has not been compared with *C. (Chama) hunua.*

Beu *et al.* (1990) described an unnamed *Chama* species (Fig. 24) from Target Gully, Oamaru (Altonian), that "is possibly conspecific with *C. huttoni*" (although exhibiting more distinct radial sculpture on the commarginal lamellae). Beu *et al.* (1990) also questioned the validity of *C. pittensis* by suggesting that it is "doubtfully distinct from *C. huttoni*". They commented on a chamid similar to *C. (Chama) hunua* recorded from Otaian beds in Northland as being distinct from all three species by virtue of its larger size (with a length up to 80 mm) and "finely spinose growth ridges rather than distinct lamallae".

Several extant chamids are similar to *C. (Chama) hunua. C. lazarus* Children, 1823 (East Indies and Australia; Fig. 25), is longer (to 100 mm), and unlike the New Zealand fossil possesses prominent, foliated (not imbricate) concentric commarginal lamellae and a beak that is not as strongly prosogyrate. The Australian *C. pulchella* Reeve, 1846 is shorter (to 50 mm) than *C. (Chama) hunua* and also has foliated concentric commarginal lamellae. A distinct difference between the two species is that *C. pulchella* has rows of foliacious ridges separated by a furrow from the umbones to the postero-ventral margin. Another extant Australian species, *C. ruderalis* Lamarck, 1819, is also shorter (to 35 mm), and differs from the New Zealand fossil species in that the right valve is quite flat compared with the inflation seen in *C. (Chama) hunua,* the imbricated commarginal lamellae bear spines which become longer posteriorly, and the beak is not as raised nor as spirally prosogyrate as that of *C. (Chama) hunua.* The Central American species *C. buddiana* C. B. Adams, 1852 (Fig. 26) is a much lighter, thinner shell and up to four times longer (to 120 mm) than *C. (Chama) hunua.* It also differs in having an elaborate sculpture of rows of elevated, fluted isolated spines.

Also similar to *C. (Chama) hunua* is the Baja, California, Miocene-Recent *C. squamuligera* Pilsbry & Lowe, 1932 (Fig. 27). *C. squamuligera* is much smaller (to 21 mm) than *C. hunua,* has concentric commarginal lamellae that are foliated with closely set, long, narrow spines on the right valve, and an internally granulose broad edge on the right valve. The extant cosmopolitan and Pliocene fossil *C. frondosa* Broderip, 1835 (California to Ecuador and the Galapagos; Fig. 28), differs from *C. (Chama) hunua* in that the heavy shell is smaller (to 75 mm) and concentric commarginal lamellae extend into the longitudinally plaited foliations. Fossil *C. lamellifera* Tenison-

Figs 24-28. Line drawings and monochromes of New Zealand fossil and Recent foreign *Chama* species. 24. *Chama* sp., right valve lateral external and internal views of Altonian, Target Gully specimen (from Beu *et al.* 1990). 25. *C. lazarus*, lateral external view of right valve and internal view of left valve (from Cox *et al.* 1969). 26. *C. buddiana*, external lateral view of right valve, internal lateral view of left and right valves. 27. *C. squamuligera*, lateral view of right valve. 28. *C. frondosa*, lateral view of right valve. (Figs 26-28 from Keen 1958.)

Woods, 1877 from the early Miocene of Table Cape, Tasmania, is smaller (to 24 mm) than *C. (Chama) hunua*, is similar in not having radiating striae, but lacks the finely spinose growth ridges that *C. (Chama) hunua* has. *C. (Chama) hunua* possesses features that together characterise it as being unlike any other chamid. The left valve of *C. hunua* was cemented to the substrate, verifying it as a *Chama* and not *Pseudochama* (Oligocene- Recent), which is attached by the right valve.

Contemporary *Chama* are sessile in shallow (0-100 m), warm waters in sub-equatorial latitudes. They wedge in crevices and attach to coral, stones, or shell masses in subtidal reef systems, boulder banks and shell hash accummulations. They often become overgrown with algae, their spines become ground down by abrasion or encrused with sediment and marine growths. Consequently, fossil chamids are usually collected abraided and broken. Right valves of *C. (Chama) hunua* are in good condition, possibly because they disarticulated soon after death and were quickly buried. The paratype left valve of *C. (Chama) hunua* is decalcified,

abraided, and has been bored, possibly by carnivores. Early Miocene New Zealand chamids are palaeotemperature indicators of a warmer geologic stage.

SUPERFAMILY: TELLINACEA de Blainville, 1814
FAMILY: DONACIDAE Fleming,1828
GENUS: *Donax* Linnaeus, 1758
Type species: *Donax rugosa* Schumacher, 1871 (by subsequent designation). Recent, West Africa.

Diagnosis: Trigonal shells, medium-sized to small, solid, inequilateral; radial sculpture present in most, at least as marginal crenulations; periostracum wanting; opisthogyrate; hinge with two cardinals, well developed laterals; pallial sinus normally present; posterior area concentrically wrinkled, internal margin strongly denticulate (Keen 1958; Cox *et al.* 1969).

SUBGENUS: *Paradonax* Cossmann & Peyrot, 1910
Type species: *Donax transversus* Deshayes, 1830 (by original designation). Miocene, France.

Diagnosis: Possessing low radial sculpture, smaller than *D. (Donax)* with lower beak; posterior laterals strong in right valve (Cox *et al.* 1969).

Donax (Paradonax) parengarengaensis n. sp. (Figs 29-30)

MATERIAL

Specimens partially broken, abraided, and decalcified (Figs 29-30). Holotype: AK 72653, left valve (top). Paratypes: AK72654 and L3937, both left valves (middle and bottom respectively). Parengarenga Group, Paratoetoe Formation, north shore, Parengarenga Harbour, NO2/f231.

AGE

Macrofossil and foraminiferal biostratigraphy confirm an early Miocene, Altonian (Burdigalian) age (Leitch 1970; Beu *et al.* 1990).

DISTRIBUTION

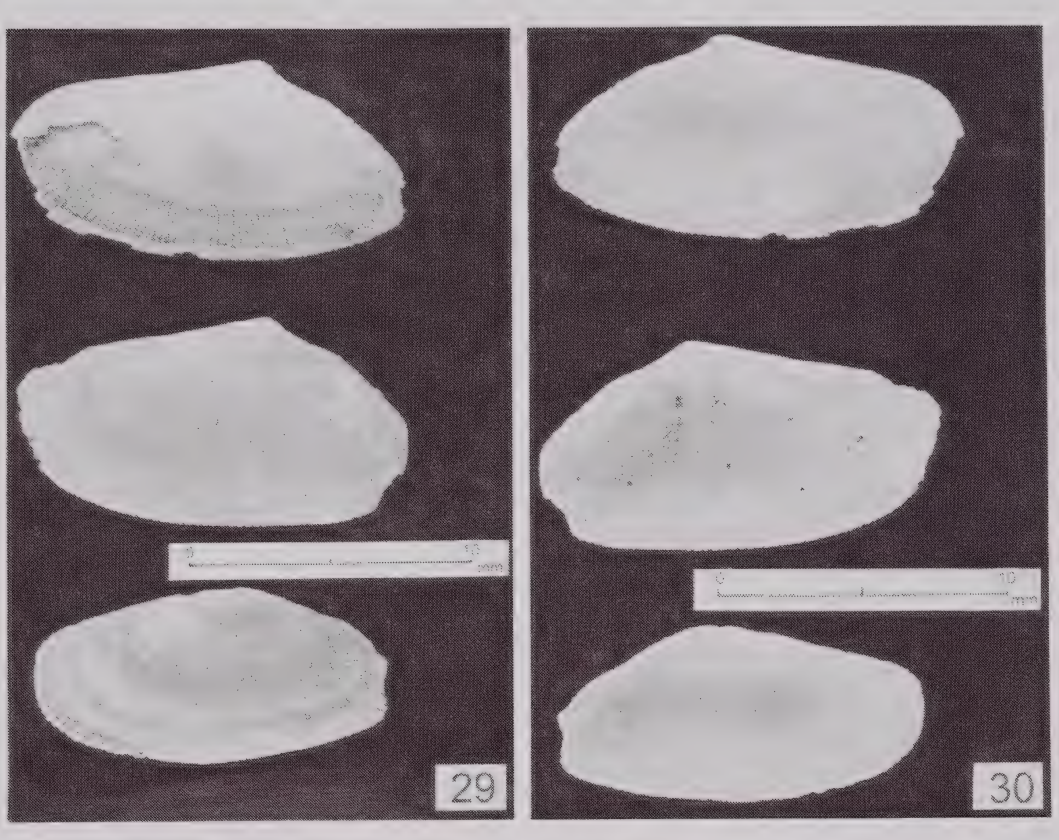
Known only from the Paratoetoe Formation, Parengarenga Harbour.

ETYMOLOGY

Named after Parengarenga Harbour, Northland.

DESCRIPTION

Shell small, solid, narrowly elongate, porcellaneous, subtrigonal. Anterior side longer than posterior, more broadly rounded. Posterior side shorter than anterior, narrower, inflation low, height 6.3-7.2 mm, length 12.3-13.9 mm, inflation 1.6-2 mm. Beak situated between posterior one-third and one-quarter, low. External sculpture of faint and weak fine radial ribbing, with punctate interspaces and occasional concentric growth striae. Nymphal plate a narrow lunate platform extending posteriorly from beak along dorsal margin. Hinge with two small cardinal teeth and one lateral tooth in right valve. Left valve accommodating sockets. Distinct pallial line, moderately large rounded pallial sinus extending nearly to valve centre. Internal margin crenulate, reflecting radial ribbing. Posterior adductor muscle scar small, ovoid. Anterior adductor muscle scar large, rhomboidal. Right valve unknown.

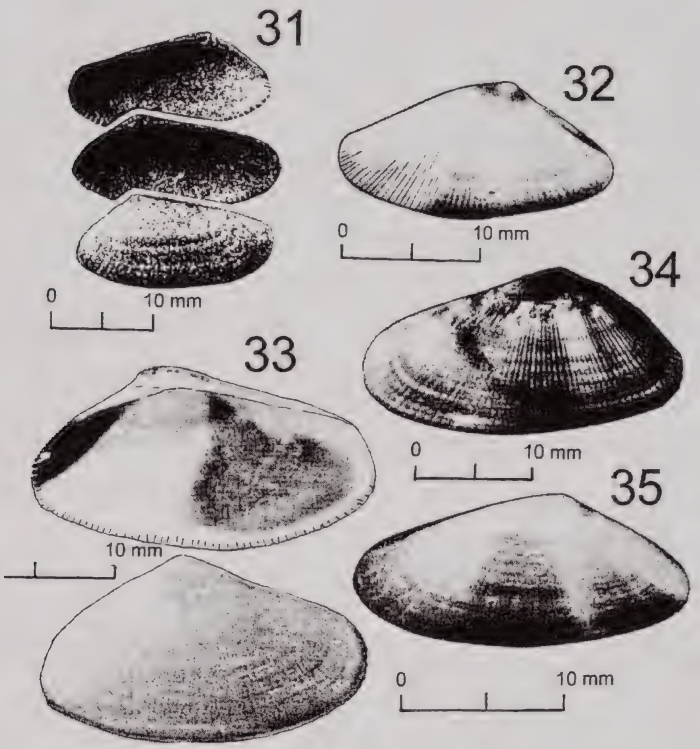


Figs 29-30. *Donax (Paradonax) parengarengaensis* n. sp. 29. Holotype AK72653, paratypes L3937 and AK72654 (top to bottom respectively); lateral view of external shell. 30. Holotype AK72653, paratypes L3937 and AK72654 (top to bottom respectively); lateral view of internal shell.

REMARKS

Shells of *Donax (Paradonax) parengarengaensis* are very small as members of the genus go. However, they are presumed to be adult, or are current-sorted, since all valves collected are of a similar size. The French Miocene fossil and subgenus type species *D. (Paradonax) transverus* Deshayes, 1830 (Fig. 31), is more trigonal in outline than *parengarengaensis*, possesses a nearly straight anterodorsal line compared to the variously curved one of *parengarengaensis*, and is gently truncated anteriorly with the anteroventral margin rising dorsally in a sharper curve. The two strong lateral teeth sockets of *paregarengaensis* are thinner and longer than those of *transversus,* and positioned at a steeper inclination on the hinge line. In both fossil species the shell inflation and internal crenulate ventral margin are similar.

Compared to *D. (Paradonax) parengarengaensis*, the Recent (Gulf of California to Panama) *Donax navicula* Hanley, 1845 (Fig. 32) has a shell that is more rounded ventrally, more rhomboidal in outline and more inflated. *D. navicula* is higher (10 mm), longer (21 mm), and has a greater inflation (3.9 mm). The uncommon, Mexico to Panama, Recent *D. petallinus* Reeve, 1854 (Fig. 33) is also a small, elongate shell, although bigger (height 11 mm; length 22 mm; inflation 3.3 mm) than *parengarengaensis*. The ventral margin of *D. petallinus* is deeper,



Figs 31-35. Monochromes and line drawings of Recent *Donax* species. 31. *Donax (Paradonax) transversus,* lateral views of internal left and right valves and external view of left valve. 32. *D. navicula,* lateral view of right valve external. 33. *D. petallinus,* lateral view of right valve internal and left valve external. 34. *D. contrusus,* lateral view of right valve external. 35. *D. gracilis,* lateral view of right valve external (all from Keen 1958).

and the outline becomes more ovoid than that of *parengarengaensis.* The also uncommon, Recent *D. contrusus* Reeve, 1854 (Fig. 34) is similar to *parengarengaensis* in having finely punctate spaces between the ribs, however, it is larger (height 16 mm; length 30 mm; inflation 5.5 mm), has differently shaped adductor muscle scars, and a coarser radial ribbing. The Recent *D. gracilis* Hanley, 1843 (Fig. 35) is the most similar in shell outline and sculpturing to *parengarengaensis.* This Peruvian species has a polished, elongate shell with the beak nearer the posterior end, like *parengarengaensis,* although it is twice the size of *parengarengaensis* (height 9.4 mm; length 22.5 mm; inflation 3.0 mm), has a differently orientated dentition, and has different shaped adductor muscle scars. Compared to Recent species of Australian *Donax, parengarengaensis* is more ovally-elongate, has a lower umbo, and appears from the left valve sockets to have strong posterior lateral teeth in the right valve. *D. (Paradonax) parengarengaensis* is unlike any known *Donax* because of a unique combination of morphological features, including shell outline, dentition, and internal scar arrangements. It is the only fossil record of the genus in New Zealand.

SUPERFAMILY: VENERACEA Rafinesque, 1815
FAMILY: VENERIDAE Rafinesque, 1815
SUBFAMILY: CHIONINAE Frizzell, 1936

GENUS: *Austrovenus* Finlay, 1926
Type species: "*Venus stutchburyi*" Gray in Wood, 1828 (by original description). Recent, New Zealand.
Diagnosis: See Finlay (1926) and Cox *et al.* (1969).

Austrovenus northlandica n. sp. (Figs 36-39)

MATERIAL

Holotype: AK 72649 (Fig. 36). Paratypes: AK 72650 (Fig. 37), L3939 (Fig. 38), AK76821, AK76823 (Fig. 39). All adult (?) specimens; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting, R12/f72.

DISTRIBUTION

Known only from the Hunua Road cutting.

ETYMOLOGY

Named after the Northland region of the North Island of New Zealand.

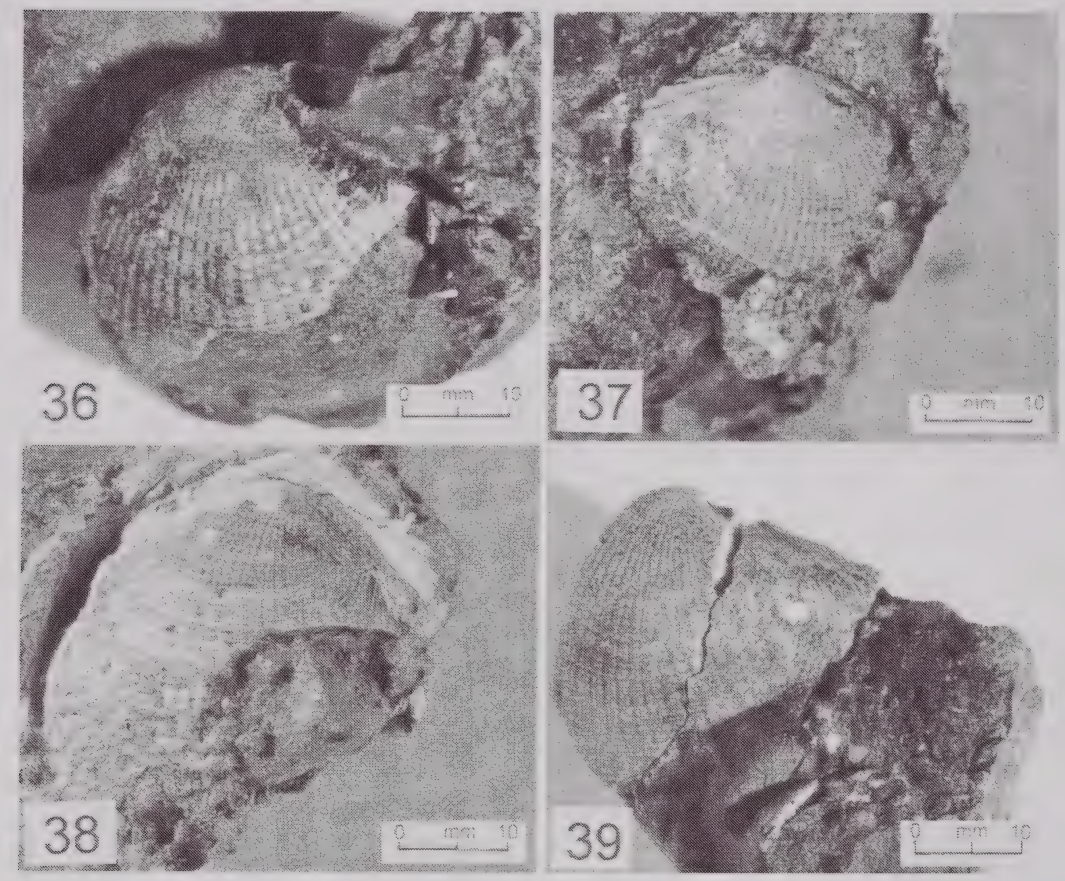
DESCRIPTION

Shell small for genus, solid, oval, height slightly less than length, height 14.1-14.6 mm, length 14-16.8 mm, inflation 4.8 mm, thick, moderately inflated, convex. Umbo low, protruding. Lunule large, unimpressed, radially ribbed, bordered by shallow depression. Margin in posterodorsal quadrant flattened, broadly rounded. Prominent commarginal cancellate sculpture of 42-47 radials. Concentric lamellae of nearly equal strength. Radial costae low, wide, rounded, flat-topped, with interstices intersected by thin, low, well-spaced, lamellae, regular near umbo, irregular near ventral margin. Ligmental nymph prominent, deep. Escutcheon defined by absence of radials, flat, narrowly lanceolate in both valves. Hinge-teeth divergent. Right valve with thick, bifid cardinal teeth and with, weak posterior lateral ridge. Left valve broadly-triangular, grooved, median with long, high, curved, posterior cardinal welded to nymph. Anterior lateral socket present. Pedal retractor scar near anterior adductor scar which is slightly narrower than posterior, both deeply impressed. Ventral margin of valve internal, bicrenate with two orders, both projecting inward and bordering ventral margin. Second order with more crenulations. Pallial line almost entire with small sinus, short, narrow, triangular, ascending.

REMARKS

The New Zealand Recent and fossil *Austrovenus* record has been complicated by the genus *Chione*. The taxonomy of *Austrovenus* is still unclear, and synonymising of some species by Beu *et al.* (1990) has resulted in only two recognised *Austrovenus* fossils. The extant *Austrovenus stutchbury* (Fig. 40) is Opoitian-Recent from the Waipaoa Beds, Awatere River, East Cape, Hawkes Bay, Clifden, and is a synonym of *Austrovenus crassitesta* Finlay, 1924 (Fig. 41). *Austrovenus tamakiensis* (Marwick, 1948) is from the Waipipian; Otahuhu Brewery well site (Fig. 42).

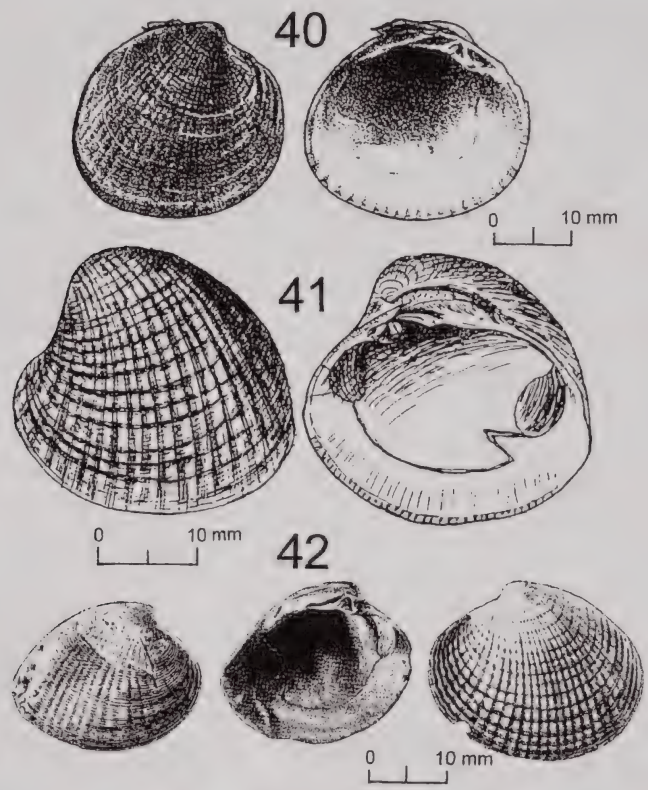
The anatomy and shell of *Austrovenus stutchburyi* differ from those of American *Chione* species and similarities are convergent (Jones 1979). Thus Finlay (1927: 470) was correct in commenting that "It [*A. stutchburyi*] compares well with no other *Chione*, and is a distinctive Neozelandic evolutionary product". *Austrovenus* is one of very few New Zealand venerids in which both radial and commarginal sculpturing are prominent. Fossil *Austrovenus* first appear



Figs 36-39. *Austrovenus northlandica* n. sp. 36. Holotype AK72649, lateral view of left valve. 37. Paratype AK72650, view of partial right valve and steinkern. 38. Paratype L3939, lateral view of right valve. 39. Paratype AK76823, view of posterior dorsal margin.

in a Waitakian assemblage exposed along the west bank of the Mataura River (F46/886313), near Brydone, Southland (Maxwell 1990). Shells from the Mataura site are small, not unlike *A. northlandica* in size, but lack the rounded, flattened margin, and a similar posterodorsal area of the lunule. Although forms of *A. stutchburyi* are similar in shape to *A. northlandica,* the shell of *A. stutchburyi* is larger, more robust, considerably more inflated, more strongly cancellated on the umbo, the escutcheon is less apparent, and the lunule is deeper, but not as broad or possessing as flattened a margin as in *A. northlandica. A. stutchburyi* forma *crassitesta* shares a triangular shape with *A. northlandica*, but is distinguishable by having thicker and more persistent concentric ridges and a deeper escutcheon.

The only other Recent *Austrovenus* species, *A. aucklandica* Powell, 1932, from the Auckland Islands, differs from *A. northlandica* by having an ovate-quadrate instead of an oval shell outline. *A. aucklandica* is less inflated than any of the forms of *A. stutchburyi*, but is similar in that respect to *A. northlandica.* However, the Auckland Island species differs in sculpture by having more radials, and by lacking concentric lamellae. The Pliocene fossil *A. tamakiensis* differs from *A. northlandica* in not being as inflated, in being more weakly sculptured, in having a relatively



Figs 40-42. Line drawings of New Zealand fossil and Recent *Austrovenus* species. 40. *Austrovenus stutchburyi* (from Suter 1915). 41. *A. stutchburyi* forma *crassitesta* (from Beu *et al.* 1990). 42. *A. tamakiensis* (from Marwick 1948).

prominent escutcheon and in lacking the flattened broadness of lunular margin. In morphology, *A. northlandica* is unlike any other *Austrovenus*.

Records of *Austrovenus* from pre-Wanganui Series rocks are extremely scarce (Beu *et al.* 1990). Matura River Waitakian *Austrovenus* are rare, corroded single valves (indicating that they did not live in the immediate vicinity), found in decimetre to metre thick sandy shellbeds interbedded with carbonaceous fine sandstone and siltstone. *A. northlandica* originally lived in a shallow, subtidal mud and sand community (no deeper than 10 m), similar to the Mataura River fossil locality. *A. northlandica* is also found as single valves, but these are broken, rather than corroded, probably because of postmortem transport. Like the Mataura River specimens, *A. northlandica* is thought to have not lived in the immediate vicinity, but locally. It is likely that *A. northlandica* lived in a similar environmental setting to that of *A. stutchburyi*, i.e. at low tide in sand, gravel or mud of harbours, enclosed bays, mudflat estuaries, and brackish streams.

SUBCLASS:	ANOMALODESMATA Dall, 1889
ORDER:	PHOLADOMYOIDA Newell, 1965
SUPERFAMILY:	POROMYACEA Dall, 1886
FAMILY:	VERTICORDIIDAE Stoliczka, 1871

GENUS: *Euciroa* Dall, 1881
Type species: *Verticordia elegantissima* Dall, 1881 (by original designation). Recent, West Indies.

Diagnosis: Shell thin to solid, white, circular or elongate-ovate in shape, usually inflated; broadly rounded anteriorly, usually broadly truncated posteriorly; shell surface covered in radial ribs; beak prosogyarate; shell interior nacreous, ventral margin crenulated; mantle line continuous and uninterrupted; hinge a cardinal tooth in right valve below beak, left valve without true teeth; internal resilium lithodesma (Cox *et al.* 1969).

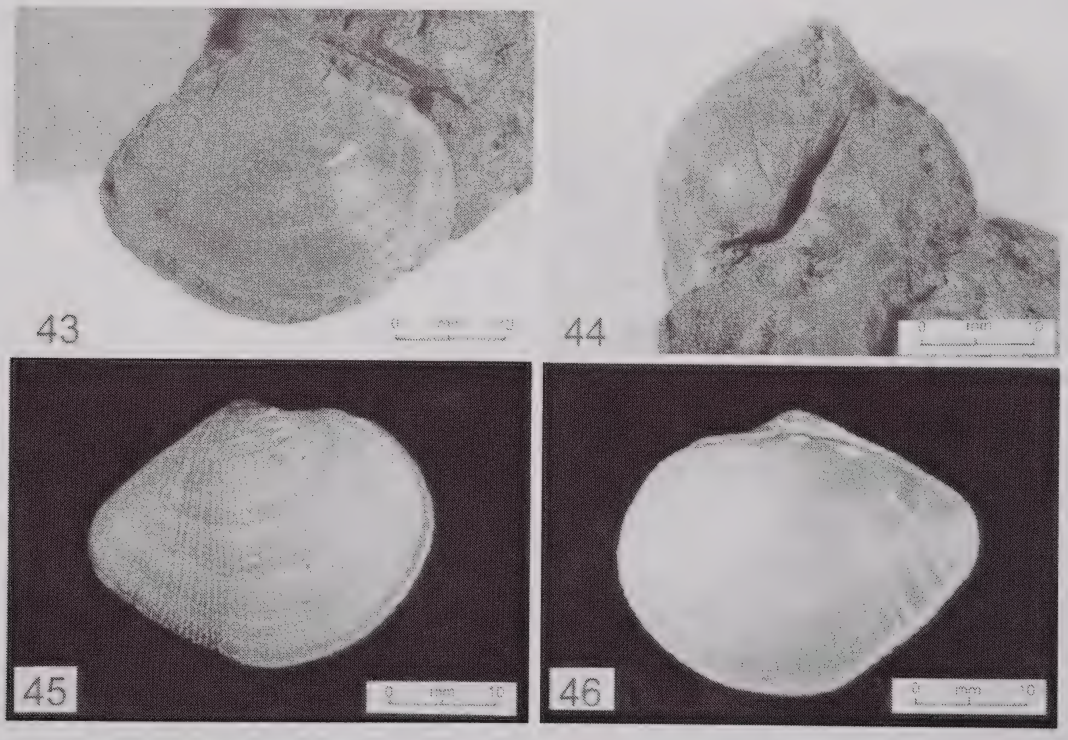
SUBGENUS: *Euciroa* Dall, 1881

Diagnosis: Valves subequal, hinge well-developed, rostrum reduced, flexure minimal (Cox *et al.* 1969).

Euciroa (Euciroa) maoriana n. sp. (Figs 43-50)

MATERIAL

Holotype: AK72657, adult right valve (Figs 43, 44); Waitakere Group, Manukau Subgroup, Nihotupu Formation, Maori Bay Member (Hayward 1976a), south end of Maori Bay, Q11/f40 (Fig. 3).



Figs 43-46. *Euciroa.* 43-44. New Zealand fossil *Euciroa (Euciroa) maoriana* n. sp. (holotype, AK72657). 43. Lateral view of right valve. 44. Dorsal view of right valve showing umbone detail. 45-46. Recent *E. galathea.* 45. Lateral external view of adult right valve. 46. Lateral internal view of adult right valve.

AGE

Pareora Series, early Altonian (Burdigalian), based on a K/Ar age of 16.8 Ma for the immediately overlying andesitic pillow lavas (Bandy *et al.* 1970).

ETYMOLOGY

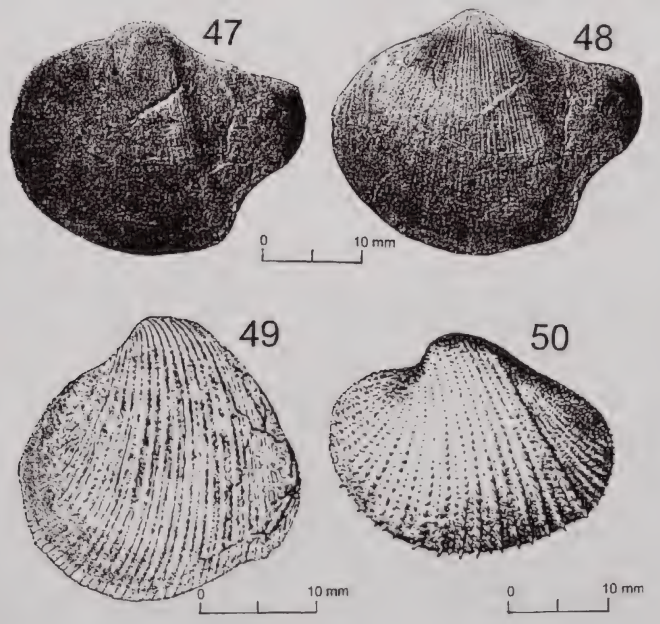
Named after Maori Bay, Motutara.

DESCRIPTION

Shell inflated, thin, slightly gaping at each end, roundly ovate in outline, height 28.9 mm, length 33.8 mm, inflation 10.6 mm. Dorsal margin narrow, broadly rounded anteriorly. Ventral margin strongly convex, posterior slightly extended to produce sub-rostrate effect. Broad, shallow depression continues from beak toward posteroventral margin designating shell posterior. Prodissoconch rounded. Beak inflated, conspicuous, prosogyrate. Lunule large, prominent. Exterior shell sculpture of 72 spaced, continuous, narrow, granulose, radial riblets separated by dense sequence of narrow, then occasionally wide, narrow radial grooves crossed by irregular, commarginal, concentric growth lines on shell disc. Radial riblets 26 on posterior flexure, 15 on rostrum. Shell finely reticulated where ornament worn away. Posterior dorsal margin almost straight. Escutcheon small, indented. Shell internal characters not seen.

REMARKS

E. (Euciroa) maoriana is distinguished from New Zealand Recent *E. galathea* (Dell, 1956a)



Figs 47-50. New Zealand fossil and foreign Recent *Euciroa*. 47. *E. ulrichi,* view of holotype left valve (from Fleming 1970). 48. *E. ulrichi,* composite of left valve. 49. *E. cistagemma,* view of right valve (from Keen 1958). 50. *E. elegantissima,* lateral view of left valve (from Cox *et al.* 1969).

(Figs 45, 46) by not having a triangular rostrum, by having a deeper, broader lunule, and by having finer, almost three times more numerous, radial riblets. *E. maoriana*, although identical in outline, also differs from *E. galathea* by having a less prominent posterior flexure, and an anteroventral quadrant that is less full and less inflated. The posteroventral margin is correspondingly straight in both species. The umbo is larger, more rounded at the prodissoconch and is not as obviously prosogyrate in *E. maoriana* as it is in *E. galathea*.

The poorly preserved New Zealand fossil *Euciroa ulrichi* Fleming, 1970 (Figs 47, 48) from the fine-grained Tarakohe Mudstone (Altonian), Tarakohe, north-west Nelson, differs from *E. (Euciroa) maoriana* by having a well-defined triangular rostrum separated from the shell disc by a distinct posterior flexure, which in *E. maoriana* is indistinct and minimal in comparison. Shell sculpture of *E. maoriana* and *E. ulrichi* consists of spaced, narrow radial riblets, increasing by interpolation and separated by radial grooves. The number and depth of these grooves and riblets differ between the species. In the holotype of *E. ulrichi*, every fourth to sixth groove may be deeper than the others. In the holotype of *E. maoriana* every ninth to tenth groove may be deeper and the corresponding ridge wider. The radial riblets of both species bear minute rounded pustules crossed by growth folds, and are higher and better defined toward the umbo than ventrally. Radial riblets tend to be poorly defined on the posterior rostrum and flexure. About 40 radial riblets occupy the shell disc in *E. ulrichi*; 14-18 on the posterior flexure and nine on the rostrum, the latter being supressed in some specimens. The holotype of *E. maoriana* has 72 radial riblets on the shell disc, 26 on the posterior flexure and 15 on the rostrum. *E. maoriana* is distinguished from the sole other New Zealand fossil *Euciroa, E. ulrichi,* by its more ovoid shape, reduced posteroventral embayment, weakened posterior flexure and number, consistency, and strength of radial riblets.

Although possessing some morphological similarities with the Recent Japanese species *E. cistagemma* Kuroda, 1968 (Pacific Ocean) (Fig. 49), *E. (Euciroa) maoriana* has many more finer radial riblets, a straighter anteroventral margin, and a very short rostrum that interrupts an oval shell outline. *E. cistagemma* does not possess a rostrum and has a trigonal shell outline. *E. elegantissima* Dall, 1881 (Florida to Cuba) (Fig. 50) is more oval in overall shell outline than *E. (Euciroa) maoriana*, and differs in having coarse radial ridges that are fewer in number (and covered in short spines), having an anteroventral margin that is not as straight. A combination of morphological features including overall shell outline, radial sculpturing, and details of rostrum and anteroventral margin, indicates that *E. (Euciroa) maoriana* is unlike any known *Euciroa*.

Euciroa is among the many molluscan taxa today restricted to, or most common in, the bathyal zone. It appears to be a widely distributed and characteristic member of the archibenthal fauna (Dell 1963). Recent species of *Euciroa* (Dell 1956b, 1963; Powell 1979) occur in depths of 475-621 m off Japan, Cuba, Florida, New Zealand, in the South Atlantic, and Indian Oceans. The Motutara bathyal assemblage seems to have existed in the upper part of the zone (c. 200-800 m), consistent with the suggestion of Beu *et al.* (1990).

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